IMAGERY AND DIVERGENT THINKING: EFFECTS OF IMAGERY INTERFERENCE, TASK CONCRETENESS AND IMAGERY INSTRUCTIONS

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ABSTRACT

In the first of two experiments, a visual monitoring task, called X-Checking, was tested to determine whether it would interfere with performance on a concurrent imagery-mediated task. Thirty six high-school students were given four tasks: (a)Picture Words, which required the generation of visual images for stimulus words, (b)Letter Tracking, in which subjects indicated the corner positions of block letters from memory, (c)Opposites, an antonym task, and (d)Sound Tracking, in which subjects said the first sound of words in a sentence. Subjects performed these tasks under No Interference (task alone), and concurrently with the X-Checking task presented at two rates for Low Interference and High Interference. On all dependent variables (e.g, task errors, response time) the X-Checking task interfered significantly more with the Letter Tracking task than with the other three. These results were interpreted in support of the claim that the X-Checking task interferes with the sustainment of visual images.

Experiment II investigated the effects of imagery interference, task concreteness and imagery instructions on a divergent thinking task. Eighty high-school students were assigned to one of four groups formed on the basis of type of question (Concrete or Abstract) combined with type of instruction (Imagery or Non-imagery). Students responded to the divergent thinking questions under No Interference (question alone) and High Interference (question concurrent with X-Checking task). The dependent variables were Fluency scores (total number of responses), Flexibility scores (number of categories used) and X-Checking errors. Fluency scores were significantly higher for Concrete than Abstract questions, and under No than High interference. Flexibility scores were higher under No interference. No differences in X-Checking errors were found between Concrete and Abstract questions. No effects were found for the Instructions variable nor for any of the interaction effects. These results were attributed to task difficulty. No support was found for the claim that sustainmemt of visual images is critical to performance in these concrete divergent thinking tasks, although the generation of images may play role. These findings are compatible with imagery models that posit distinct imagery processing components rather than an undifferentiated imagery ability.

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CHAPTER I

INTRODUCTION

Aristotle believed we could not think without images (Humphrey, 1963). Since Aristotle's time, this notion of imagery's preeminent role in thinking has been a point of debate for philosophers and an issue of heated controversy for psychologists since their discipline's infancy (Hilgard, 1981). Imagery is often credited with a privileged role in creativity, a claim supported by numerous testimonials from scientists and artists (Shepard, 1978).

One component of creativity is divergent thinking, defined as the capacity to generate a number of different potential solutions to a problem. Divergent thinking is considered to be an essential element in models of problem solving (Dewey, 1910; Gagne, 1966; Guilford, 1967; Wallas, 1926) and in accounts of creativity (Guilford, 1967; Osborn, 1963; Parnes, 1967; Torrance, 1965).

The question at hand concerns the role of visual imagery in divergent thinking. Given that imagery has been proposed as one format for cognitive representation and as a distinct mode for processing information (e.g., Paivio, 1971; Richardson, 1969), it is legitimate to wonder about the role of imagery in divergent thinking. Does imagery have a role in divergent thinking? If so, is it task-specific to concrete tasks? Is it subject-specific, only functional in those individuals who are high-imagers? Do instructions to use imagery enhance divergent thinking? How do these variables interact with each other? These questions will be addressed in the present study.

The nature of the relationship between visual imagery and divergent thinking warrants elucidation. Aside from the numerous anecdotal reports in support of visual imagery's role in divergent thinking, most of the studies in this area have been correlational, attempting to demonstrate an association between imagery ability and divergent production. Studies to date have looked at subject variables, as indexed by imagery test scores, but no research has yet been undertaken to investigate task and instructional variables. Both task concreteness and imagery instructions are presumed to engage the imagery mode, and have been found to produce significant and reliable effects in tasks such as paired-associate learning, free recall and mnemonic training. In the present study, these variables were manipulated to determine whether similar effects would be observed in divergent thinking tasks.

A critical issue in the present study and to imagery research in general remains one of validating the presence of imagery. The traditional approaches used to manipulate imagery have consisted of using imagery instructions, varying task concreteness or selecting subjects on the basis of imagery ability. These approaches do not ensure that subjects are actually using imagery during the experimental task. Thus, the basis for assuming that imagery can account for 'treatment' effects can be tenuous. To address this problem, the first study tested a visual monitoring task to determine whether it interfered with the use of imagery. This interference procedure was subsequently used in the second study to disrupt the use of imagery in divergent thinking tasks.

The second study was designed to address the following questions: Can visual imagery be shown to contribute to divergent thinking? Is imagery's role in divergent thinking task-specific? Do instructions to use imagery enhance divergent thinking? Do high-imagers perform better than low imagers in divergent thinking tasks?

A review of the literature is presented in Chapter Two. The theoretical and empirical bases for imagery's role in cognition will be presented, followed by a discussion of the methodological issues critical to the present investigation. The research on imagery in divergent thinking will be reviewed. Chapter Three describes the methodology and results of the two studies undertaken. The first study tested a visual monitoring task to determine whether it interferes with performance on a task that relies on visual imagery. The second study investigated the effects of imagery interference, imagery instructions and task concreteness on performance in a divergent thinking task. A general discussion of the findings and their implications are contained in Chapter Four.

CHAPTER II

REVIEW OF THE LITERATURE

A general overview of the theoretical and empirical bases for imagery as a cognitive process is presented, followed by a detailed review of the empirical evidence of imagery's role in divergent thinking. The imagery and divergent thinking variables relevant to this study will then be discussed.

Imagery and cognition: Theoretical and empirical foundations.

The essential claims put forth by imagery theorists have to do with imagery as a format and process for mental representations. The format of imagery is presumed to preserve the figural, spatial, and appearance information available in visual perception. Imagery is the mode of representation for non-verbal thought.

Many theorists (e.g., Bruner, 1964; Piaget and Inhelder, 1971; Neisser, 1976, Werner and Kaplan, 1963) have incorporated imagery into their accounts of cognitive functioning. The imagery theories of Kosslyn (1980) and Paivio (1971) are the most detailed and comprehensive, and have generated much of the empirical work.

Paivio (1971, 1975, 1983) has incorporated imagery into a model for associative memory. For Paivio, imagery provides a format for "encoding, storing, organizing and retrieving information concerning concrete objects and events...The other system (verbal) is specialized for dealing with information concerning discrete linguistic units and structures" (1975,p. 635). The processes operating on images are presumed to be distinct from those operating on the verbal codes. The former are described as synchronous and parallel, whereas the processes for the linguistic code are presumed to be sequentially organized. The basic assumptions of Paivio's theory are that images have perceptual-like qualities, that they are stored as 'imagens' in long-term memory, and that learning involves the formation of associations of images with each other and with 'logogens', their verbal counterparts.

Whereas Paivio focused on the function of imagery in memory, Kosslyn and Shwartz (1980, 1982) attempted to delineate the structure of imagery representation and processing. Their goal was to specify the nature of the mental structures and processes that allow images to serve as repositories of information in memory. They postulated data structures in long-term memory, which can be displayed in short-term memory on a 'visual buffer'. A number of processes operate on the data structure in long term memory to find and generate images. Other processes (e.g., scan, rotate, zoom, pan) operate on the image displayed on the visual buffer. This theory differs from Paivio's in its goal and in the nature of the information stored in long term-memory (imagens vs. propositions). Both theories ascribe to the imagery representations 'privileged properties' and specialized processes, and give images percept-like qualities.

Over the last twenty years, research in different fields has supported the claim of imagery as cognitive process and a distinct format for mental representations. A brief, general overview of this work follows.

Much of the imagery research has focused on the similarities between visual imagery and visual perception. Results of these studies appear to demonstrate that we operate on images much like we operate on visual percepts. For example, Finke and Schmidt (1977) reported that the McCollough effect in visual perception, where predictable visual after-effects follow the presentation of visual stimuli consisting of horizontal and vertical bars, was obtained when naive subjects were asked to imagine the stimuli. The functional equivalence between imagery and perception has also been demonstrated in studies comparing reaction times between perceived and imaged objects in mental rotation studies (Shepard & Cooper, 1980), scanning times for perceived and imaged figures (Kosslyn, Ball & Reiser, 1978), and pattern verification (Podgorny & Shepard, 1978).

The claim that imagery and perception share processing systems is further supported by studies in modality-specific interference. An early study by Perky (1910) demonstrated that when subjects were asked to image a common object while dim facsimiles were presented to them on a screen, they tended to report an image rather than a perceptual experience. In a systematic replication of Perky's study, Segal & Fusella (1970) showed that the generation of irrelevant visual images interfered more than irrelevant auditory images with the detection of visual signals. Conversely, auditory images interfered more than visual images in the detection of auditory stimuli. A similar pattern of findings was reported by other investigators (e.g., Pellegrino, Siegal, and Dhawan, 1975; Warren, 1977) who found verbal distracting tasks to interfere more with memory for words than pictures, whereas the opposite effect was obtained for nonverbal distractors . Modality-specific interference effects have also been reported by Brooks (1967) and Saltz & Donnenwerth-Nolan (1981). These studies support the claim for shared processes between imagery and perception, and for distinct processes for the imagery and auditory/language systems. Marks (1983) commented that these findings have not been integrated into models of attention, although they can easily be explained by multiple-resource theories (e.g., Kahneman, 1973; Navon and Gopher, 1979) which predict the interference effect on the bases of competition for resources dedicated to visual processing (Wickens, 1984).

These modality-specific interference studies have prompted a number of investigators (eg., Glass, Eddy and Schwanenflugel, 1980; Klee and Eysenck, 1973; Kaufmann, 1981) to use this experimental paradigm as a procedure for manipulating imagery. They attempted to disrupt the use of imagery by presenting a concurrent visual perceptual task. In this way, they could compare task performance under the conditions of imagery interference and non-interference, and thereby assess the contribution of imagery to task performance.

A neurological basis for the distinction between imagery and verbal processes has been suggested by localized brain lesions that disrupt imagery but not language processes (Humphrey & Zangwill, 1951; Jones, 1974), and by EEG studies (e.g., Robbins & McAdams, 1974) reporting greater activation of the right hemisphere concurrent with the use of imagery. Although localization of cognitive functions (i.e., language processes in the left hemisphere, spatial and imaginal abilities in the right hemisphere) is far from clear cut, reviews by Ley (1983) and by Paivio and teLinde (1982) support the notion that, for most people, language processes are lateralized to the left hemisphere whereas a number of processes presumably mediated by imagery (e.g., episodic memory for non-verbal stimuli, spatial reasoning) are lateralized to the right hemisphere.

Investigation of individual differences in imagery abilities has provided convergent support for the idea that imagery is a distinct format of representation that is functional in cognition. Psychometric data have consistently shown that verbal abilities are factorially independent from imaginal and spatial abilities (Di Vesta, Ingersoll and Sunshine, 1971; Guilford, 1967). Imagery abilities have been assessed through the use of objective tests (e.g., The Space Relations subtest of the Differential Aptitude Test; Bennet, Seashore and Wesman, 1947) and subjective measures (e.g., Test of Visual Imagery Control; Gordon, 1949). Numerous studies have shown significant positive correlations between high scores on imagery tests and performance on tasks presumed to be mediated by imagery. For example, McKelvie & Demers (1979) identified high and low imagers according to results of the Vividness of Visual Imagery Questionnaire. High-imagers performed better than low imagers in long-term recall for concrete words and pictures but not for abstract words. High imagers, identified by the aforementioned test, perform better than low-imagers in paired-associate learning for concrete words (Rossi & Fingeret, 1977), and in tests of picture recognition (Marks,1983). High imagers, as identified by the Betts Questionnaire upon Mental Imagery, showed stronger heart-rate decelerative conditioned responses to an imaged conditioned stimuli (Arabian & Furedy, 1983). These studies indicate that individuals vary in their imagery abilities, and that these abilities are functional in tasks which are presumed to be mediated by imagery.

The last area of investigation to be considered is the seminal work carried out by Allan Paivio and his colleagues (see Paivio, 1971 and 1983 for reviews) who have attempted to integrate imagery into models of associative memory. Paivio has argued that concrete words are more likely to evoke imagery than abstract words, and that this imagery-evoking capacity of concrete words accounts for their superiority over abstract words in paired associate learning, free recall and recognition memory. These effects of word imagery/concreteness are probably the most reliable and robust in the imagery literature, and the imagery interpretation (see Paivio, 1983, for a review) of these effects remains the most viable vis-a-vis those that rely on linguistic or semantic attributes, or on propositional models (e.g., Anderson, 1978; Pylyshyn, 1973, 1981).

The above overview was brief and selective, presented to outline the essential claims of imagery theories and to summarize findings in areas of research that have given convergent support to the proposition that imagery is functional in cognition.

Methodological issues. As Kaufmann (1980) and Shepard (1978) have noted, the privacy of imagery gives it its idiosyncratic quality or 'semantic individuality'. Its privacy also poses methodological problems. If we are to bring imagery under greater experimental control, we must first be able to observe it or validate its presence. The difficulty in validating the presence of imagery constitutes the central methodological problem in imagery research. Relative to this problem, other methodological issues such as comparability of imagery instructions, validity of imagery tests, and tacit demands appear less critical.

The procedures typically used to 'manipulate' imagery (i.e., use of imagery instructions or concrete materials, and the selection of 'high imagers' on the bases of test scores) may make it more likely that subjects will use imagery during the experimental task but in no way can they guarantee or confirm that subjects actually used imagery. Furthermore, such procedures cannot rule out the use of imagery by the 'control' group.

Self-reports have often been used to confirm the use of imagery during the experimental task. Although self reports provide valuable information, they cannot by themselves constitute sufficient evidence, particularly given the problems associated with the privacy of the imagery event. Consider the situation where two persons reported the use of imagery. It is difficult to determine if the vividness or flexibility of these images were similar, or whether these images actually had a functional role in the task. In fact, it is possible that the imagery of a person who reports 'no imagery' is identical to that of a second person who reports 'strong' imagery. In short, self-reports cannot stand alone as a procedure for validating the presence and functional role of imagery.

The hope for a reliable physiological or neuropsychological measure of imagery has not yet materialized (Anderson, 1978; Zikmund, 1972).

In the absence of a procedure to validate or confirm the presence of imagery, an alternative is to employ one that disrupts or inhibits the use of imagery. Such procedures are suggested by the modality-specific interference studies. Variations of this procedures have been used (e.g., Kaufmann, 1981; Saltz and Nolan, 1981) to investigate the effect of imagery interference on peformance in various tasks. For example, Klee and Eysenck (1983) found that speed of comprehension for concrete, high imagery sentences was selectively disrupted by a concurrent visual-spatial memory task whereas abstract sentences were more disrupted by a verbal task. By using a procedure that selectively disrupts imagery, we can assess the role imagery plays in a given task by comparing conditions where it was and was not disrupted. Thus, a selective interference procedure appears to provide the researcher with an objective way of controlling for the use of imagery during the experimental task.

Imagery and divergent thinking: Theoretical bases.

Kaufmann (1980) has provided the most comprehensive analysis of the role of imagery in problem solving, an analysis that applies to divergent thinking. He adopts the position that imagery is mainly functioning within linguistic representation, as ancillary to language. He argues that imagery is particularly well suited for the transformational aspects of thinking, those aspects that provide problem solvers with novel information. Although transformational operations may be carried out faster and more easily through language, the transformational potential of language is limited by its 'semantic conventionality' (Shepard, 1978, p. 156, refers to the same idea in terms of 'social conventionality'). Imagery, owing to its 'semantic individuality', can assist verbal thinking when the problem solving task takes on a high degree of novelty. Thus, he links imagery to the discovery and language to the generalizing functions in thought. In the initial discovery phase of problem solving, imagery plays a predominant role, while subsequent transfer activities will increasingly depend on linguistic representation. With increasing task-familiarity language will inject speed, stability and generality into problem solving activity. Aside from the idiosyncratic nature of images, Kaufmann claims that another characteristic of imagery, that of parallel or synchronous processing, is also vital to problem solving. He states:

> ...imagery may have a specialized and important job to do in the form of simultaneous organization of information which consists of bringing together hitherto unrelated pieces of information and making it possible to examine them together in a unified or unifying image....Visual imagery is especially adapted to the simultaneous organization of information that is needed in the initial, exploratory phase in problem solving,... whereas the verbal symbolic system may have its most important function in a subsequent, sequentially organized analytical stage of problem solving... (p. 124,125).

One variable found to be critical in imagery research (e.g., paired associate learning) is missing from Kauffman's (1980) account: task demands in the concrete/abstract dimension. When a problem requires the manipulation of concrete aspects of a stimulus and when the stimulus is imagable, then it is easy to accept his analysis. Some problems however, are abstract and the objects of the problem are hard to capture with images. Consider this question: In how many ways does logic assist morality? The point here is that imagery's role in problem solving and divergent thinking may not be solely the function of task novelty, as Kaufmann suggests, but also of task demands and stimuli characteristics along a concrete/abstract dimension. Thus, consistent with imagery research in other areas, concreteness must be included as a task variable in any analysis of imagery's role in divergent thinking.

Kaufmann's conclusion on the role of imagery in problem solving (i.e., provides flexibilty for novel tasks) make intuitive sense, but is supported more by anecdotal than empirical evidence. His conclusion was premised on the idiosyncratic nature of imagery and on the synchronous quality of imagery processing. Another argument, more powerful and supported by empirical data, can be added to buttress Kaufmann's conclusion. It goes as follows: imagery is particularly well suited, relative to verbal representations, to provide figural detail, appearance and spatial information about an object or event. An image of an object is more like an object than its verbal representatation, or, as Kaufmann (1980) put it, "images come nearer than words to being instances of the concept they represent... they may be regarded as quasi-instantiative particulars..." (p. 15). This allows us to mentally explore and manipulate such an object almost as if it were in front of us. This manipulation can reveal different aspects of the object. As Shepard (1978) has noted, "...the richness of concrete visual imagery, together with its structurally 'isomorphic' relation to the external objects, events or processes that it represents may well permit the noticing of significant detail and relationships that are not adequately preserved in a purely verbal formulation" (p. 156). It allows us to test possibilities, and thus assists problem solving. We know that where tasks permit manipulation of objects, the degree of manipulation significantly affects the number and flexibility of responses to a problem task (Torrance, 1963). In the absence of the object, its image can be manipulated.

A central hypothesis about the role of imagery in divergent thinking emerges from the above discussion. When the task is concrete, imagery is expected to contribute to the flexibility more than to the fluency component of divergent thinking. Imagery should assist in the production of different kinds of responses but not necessarily contribute to the number of responses within each class. For example, in the 'Uses of Bricks' task, imagery will contribute more to the flexibility score (different kinds of uses such as a building material, as a weight, weapon, ruler, etc.,) than to the fluency score (total number of responses), since the production of numerous responses for one category (e.g., building a house, a church, an apartment buliding, a wall) is presumed to be mediated by verbal processes. The role of imagery would be minimal in abstract tasks.

Imagery's role in divergent thinking: Empirical evidence.

Practically all of the available evidence of the role of imagery in divergent thinking is correlational. This evidence is reviewed below.

Hargreaves & Bolton (1972) factor analyzed the most commonly used test of creativity to determine whether creativity is a unitary dimension across these tests, and to determine the degree of relationship between these and tests of ability. Ten and 11 year-old boys and girls served as subjects. Although secondary to the main purpose of the study, imagery ability, as measured by performance on a paired-associate task using concrete words and imagery instructions, showed a moderately high correlation ($r=.56$, $p<0.001$) with performance on divergent thinking tests.

Durndell and Wetherick (1976) investigated the relationship between two self-report measures of imagery control and vividness, and performance on three cognitive tasks (divergent thinking, problem solving and concept task). The divergent thinking task included verbal (uses of a shoe) and figural (draw as many things as you can with '○ ○') stimuli. In addition, some subjects received imagery instructions whereas others received comparable non-imagery instructions. Subjects were also asked to rate their use of imagery during the experimental tasks. The major finding was a significant superiority of high imagers (for imagery control) on the divergent thinking measures. The ratings given by subjects of their use of imagery whilst performing the divergent thinking tasks correlated significantly (ranging from 0.58 to 0.29, $p<.05$) with their performance on these tasks. The effects of instructions were not significant.

The above study points to some important issues. First, self reported use of imagery showed a stronger correlation with the divergent thinking task using a verbal than a figural stimulus, supporting Paivio's (1971) claim that concrete words can evoke imagery just as figural stimuli can. Thus, it cannot be assumed that a task is 'verbal' simply because it uses words as stimuli. Second, the correlation between self reported use of imagery and task performance gives a measure of support to the use of self-reports in imagery research. Third, the negative results reported for imagery instructions are not surprising. While little information is given about the exact nature of these instructions, it appears that they were weak. They were brief, written instructions without any elaboration. Such instructions are usually ineffective.

Two other studies revealed a relationship between imagery ability and divergent thinking. Kaufmann (1981) tested high-school students on the Uses Test (e.g., uses for a brick, shoe, etc.). Performance on this test correlated significantly with performance on a measure of spatial manipulation, but only in the later stages of the task. Scores on the divergent thinking task were summed over time intervals (first, second, third and fourth minutes of the task). The predictive efficiency of the spatial ability test increased with production time ending in a significant correlation between spatial manipulation score and ideational fluency score. Mode of task presentation (verbal vs. visual) was not significant. No significant sex differences were found. One interesting finding in this study is the relationship between working time and predictive efficiency of the imagery test. These results were interpreted as follows: imagery is presumed to become active in the later stages of production, after the conventional and stereotyped responses have been given. Although this interpretation is feasible, Kaufmann (1981) does not provide evidence from his own study to demonstrate that responses given later in production were indeed more original.

Lastly, evidence of a relationship between imagery ability and divergent thinking emerged out of a study by Kosslyn et al. (1984) designed to assess distinct imagery abilities in the context on his model of imagery processing. A significant and moderately high correlation was reported between a visual/spatial manipulation test and the 'Uses' task.

Kaufmann (cited in Kaufmann, 1980, p.140) has produced the only study on the role of imagery in divergent thinking using an experimental design. Subjects responded to an ideational fluency task under two conditions: visual and auditory interference. The former consisted of instructing subjects to look at cards with colored letters, whereas in the auditory interference subjects had to listen to letters as they performed the fluency task. It was expected that visual stimuli would interfere more with the fluency task than auditory stimuli. Significant results were obtained only for males. This study is more important for its methodological procedures than for its results. It attempts to exercise greater experimental control over the subjects' use of imagery. However, the approach shows serious weaknesses. The most significant is that the experimenter did not report on how he determined whether the interference procedure was operative. There was no way of establishing the extent to which subjects attended to the interference stimuli.

In summary, the theoretical and empirical bases for the claims of imagery as a distinct mode of representation and information-processing were reviewed. The role of imagery in problem solving was then considered, in particular Kaufmann's (1980) proposal that imagery provides flexibility in problem-solving tasks that are novel. Applied to divergent thinking for concrete tasks, it is expected that imagery will facilitate flexibility (i.e., the generation of different types or classes of responses), but not fluency (i.e., generation of instances of the same class or type). Imagery is not expected to contribute to divergent thinking in abstract tasks.

Imagery variables potentially relevant to divergent thinking.

Subject, task and instructional variables potentially relevant to divergent thinking are considered below.

Subject variables. If individuals differ in their use of imagery and if imagery plays a role in divergent thinking, then such differences are relevant to an individual's performance in a divergent thinking task.

Richardson (1980) distinguished between coding ability and coding preference. Coding ability refers to the person's capacity to generate vivid images, to his self-reported control over his imagery, and/or his performance on tasks (e.g., visual-spatial manipulation) that are presumed to be mediated by imagery. Coding preference refers to differences in preference for the use of one representational mode or another (i.e., visualizer vs. verbalizer).

Most of the research on individual differences in imagery has been concerned with imagery ability, as measured by self reports of imagery vividness (e.g., the Marks' Vividness of Visual Imagery Questionnaire, Marks, 1973), or control (The Gordon Scale of Imagery Control, reprinted in Richardson, 1969), or by performance on an objective test such a The Minnesota Paperboard Form. In respect to divergent thinking, correlational studies have found that imagery control (but not vividness) and visual-spatial ability are associated with enhanced performance in divergent thinking tasks (Durndell & Wetherick, 1974; Kaufmann, 1981).

The second approach to individual differences is to view imagery as a coding preference. As noted by Richardson (1978), the crucial question is not how well someone can employ a given mode of symbolic representation, but which is his preferred mode. Coding preference will make it more likely that a person will use that mode of representation during the experimental task, irrespective of the level of ability. Coding preference can be assessed by using the Individual Differences Questionnaire (Paivio, 1971; Paivio & Harshman, 1983).

Coding preference is of interest because it has not been investigated in the context of divergent thinking, and because it can be expected to interact with two of the other variables in question: interference and imagery instructions. In general terms, it is expected that performance of individuals who show an imagery coding preference (visualizers) will not be affected by imagery instructions because they are already using imagery. Furthermore, visualizers could find the interference procedure particularly disruptive to their performance, because their habitual mode of representation is being disrupted.

Two other subject variables, age and gender are potentially relevant to the present studies. The age variable is pertinent in view of the claims of Piaget & Inhelder (1971) and of Bruner (1964) that imagery is particularly functional in the earlier stages of cognitive development but that it plays a more limited role in later stages. Developmental effects have been reported in the ability of subjects to respond to imagery instructions, with older children (above age seven) benefiting more from instructions than younger children. The strength of the relationship varies for different tasks (e.g, paired-associate and prose learning, see Pressley, 1977, for review).

In respect to gender as a subject variable, sex differences have not been found in imagery vividness (Sheehan, Ashton & White, 1983) or imagery control (Forisha, 1983). However, sex differences were found in five of the six factors of Paivio's Individual Differences Questionnaire, and have been consistently observed in the area of spatial abilities (Maccoby & Jacklin, 1974), including in performance in the mental rotation task (Tapley

& Bryden, 1977). Typically, by early adolescence boys tend to perform better than girls on these tasks. Given these findings, it is possible that a modality-specific interference procedure based on visual-spatial tasks will affect males and females differently. These factors must be considered in the selection of experimental and interference tasks.

Task variables. Task variables can vary along a concrete-abstract dimension, a dimension that has been pivotal in imagery research. Paivio, Yuille & Madigan (1968) reported that concrete words were more likely to arouse images than abstract words. The imagery-evoking capacity of concrete words results in their ease of recall in paired-associate tasks and free recall (Paivio, 1983).

Elaborating on the concrete-abstract dimension, Singer (1979) suggested that "the imagery system provides the basis for considerably more detail about a specific event or interpersonal transaction" (p.32). Similarly, Slee (1983) proposed that imagery is particularly useful when the solution to a task requires figural or appearance information rather than conceptual information. For example, imagery may not be required to remember what was seen but becomes important for recalling how something looked.

Considering the above, imagery may be functional in those divergent thinking tasks where the stimulus is concrete and where figural and appearance information is critical to performance (e.g., give as many different uses as you can think of for a cardboard box). In contrast, imagery may not be necessary for abstract divergent thinking tasks where conceptual and semantic information is critical (e.g., give as many similarities as you can think of between a computer and a mind). In short, task concreteness may be a critical variable to imagery's role in divergent thinking.

The attending demands of a task will also affect the likelihood of imagery being used. As already noted in the discussion of modality-specific interference, tasks demanding visual monitoring or the continuous involvement of visual perception will inhibit or disrupt the use of imagery. The interference effects of visual perceptual activities on imagery processes have been used as a way of experimentally controlling for the use of imagery (e.g., Klee & Eysenck, 1973; Kaufmann, 1980). We could therefore expect that the use of visual imagery for a divergent thinking task could be disrupted by a concurrent visual processing task.

Imagery instructions. Imagery instructions have been used extensively in imagery research as a way of manipulating imagery. They have been found to enhance performance in paired associate learning (Paivio and Yuille, 1967) and free-recall (Richardson, 1976), improve prose recall in children (Pressley, 1976), facilitate concept acquisition (Katz and Paivio, 1975) and improve performance in a syllogistic reasoning task (Shaver, Pierson and Lang, 1975). Richardson (1980) has noted that imagery instructions have "demonstrated consistent, reliable and substantial improvement in performance " (p. 71) across various tasks and conditions. This claim, however, is not supported by other researchers (e.g., Anderson and Kulhavy, 1972; Durndell and Wetherick, 1976; Tirre, Manelis and Leicht, 1979) who have found imagery instructions to have no effect on task performance.

The question of effectiveness of imagery instructions is hard to evaluate given the differences between studies. There is little consistency in the wording, length or mode of presentation of instructions. Furthermore, instructions have been used with different age-groups and tasks. To my knowledge, no attempt has yet been made to systematically manipulate these instructional variables within one study. There appears to be a trend whereby for complex tasks, such as prose comprehension, instructions become more effective for older children. Generally, 'strong' instructions which provide for practice and feedback tend to be more effective than 'weak' instructions that merely suggest the use of imagery.

In spite of the somewhat inconsistent reports as to the effectiveness of imagery instructions, their popularity as a research tool and possible practical applications of imagery instructions provide compelling reasons for considering them in relation to divergent thinking.

Factors in divergent thinking relevant to the present study.

A complete review of the divergent thinking literature is beyond the scope of this paper. Only those variables relevant to the present studies are reviewed below.

Sex differences have been reported with divergent thinking tasks, but these reports are very inconsistent (Maccoby and Jacklin, 1974). For high-school students, the age-group in question for this study, no significant sex differences have been reported (Bieri, Bradburn & Galinski, 1958; Kaufmann, 1981).

Task demands and instructions have been reported to affect divergent thinking, although here again the results are not consistent. Surkes (1979) found no effects for six types of instructions on overall divergent thinking performance of Gr. 7 students, although there were interactions between sex and type of instruction. Surkes recommended using exemplary/maximum instructions, which provide clear directions about the expected behavior and examples of possible responses.

Perhaps the most relevant variable is amount of time alloted for the task. Christensen, Guilford & Wilson (1957) replicated previous findings showing that rate of production of responses is virtually constant up to about 10 to 12 minutes, and that original and novel responses are given in the later stages of production. As noted above, Kaufmann (1981) has confirmed these findings with a 4 minute response-time. Given these results, it appears that a working period of at least 4 minutes should be allowed for the divergent thinking task.

Lastly, a study by Torrance (1963) showed the effect of sex stereotyped stimulus objects on divergent production. Boys suggested more possible improvements to a fire truck, but girls suggested more for a nurses kit. The researcher should therefore attempt to use stimuli that are unlikely to generate sex-stereotyped responses.

Summary and statement of the problem.

There appears to be ample evidence to support the proposition that imagery is functional in cognition, particularly to performance in tasks that call for the manipulation of concrete, figural and/or spatial information. It is therefore legitimate to wonder about its role in divergent thinking.

The modality interference effect, whereby concurrent visual processing tasks appear to disrupt the use of imagery, has been used as a procedure for the experimental manipulation of imagery usage. An elaboration of this approach was used in this study. The first experiment was designed to test a visual monitoring task to determine whether it selectively disrupts imagery but not language processing. The goals were to address the methodological issue of validating the presence of imagery, and to develop a procedure to be used in the second study to interfere with the use of imagery in the divergent thinking tasks.

The above review of the studies on imagery and divergent thinking revealed that there is a strong relationship between high imagery ability, as measured on tests of imagery control and visual spatial ability, and divergent thinking. These correlational data are suggestive but, by their very nature, are insufficient to establish the role of imagery in divergent thinking. The sole study using an experimental design is important primarily due to the researcher's attempt to control imagery through a selective interference procedure, but the results of the study are difficult to interpret due to methodological weaknesses (e.g., lack of control over subject's compliance with interference task).

The present study follows Kaufmann's (1980) lead and extends the investigation of imagery's role in divergent thinking to include variables which have proved critical in other areas of imagery research. These variables are: concreteness of stimuli, imagery instructions and the subjects' preference for either the imagery or verbal mode. The age variable is one of considerable interest to imagery researchers but practical considerations dictated that it not be included in the present study. Subjects were high-school students. As already noted, previous research in divergent thinking has not revealed sex-differences in these tasks. However, sex difference may arise from the differential responses to the interference task. Thus, the possible effects of sex differences will be controlled through subject allocation procedures, but are not of primary interest.

The basic question to be addressed in the second experiment is whether imagery plays a role in divergent thinking, and whether it contributes more to the flexibility than the fluency component, as Kaufmann (1980) claims. Imagery is expected to play a role for concrete but not for abstract tasks, consistent with findings on other tasks such as paired-associate learning and sentence comprehension. The effects of instructions are expected under certain conditions: imagery instructions should facilitate performance for concrete but not abstract tasks, and should depress performance under interference conditions since the instructions would be in contradiction of task demands. It is also expected that imagery instructions will be differentially effective for visualizers and verbalizers, since visualizers should be using imagery spontaneously. This potential interaction between imagery instructions, task demands and subject variables is of practical significance. If we can specify more precisely the conditions under which instructions facilitate divergent thinking performance, we can then apply these findings to instructional programs that use imagery instructions to teach problem solving or creativity.

CHAPTER III

METHOD

Two experiments were conducted. The purpose of the first experiment was to determine whether a visual monitoring task would show a selective interference effect. It was expected that this task would disrupt performance on a concurrent task presumed to require the sustainment of visual images but have no detrimental effect on language mediated tasks or on a task that required only the generation, but not the sustainment, of images. The goal of the first experiment was to develop a procedure that could be used to interfere with the use of imagery in the second experiment.

The second experiment was designed to determine the effects of imagery interference, task concreteness and imagery instructions on performance in a divergent thinking task.

Experiment I

The first experiment was designed to test a visual monitoring task as a selective interference procedure. This task, called the X-Checking task, was not expected to interfere with the generation of images but to disrupt the sustainment of images. It should not significantly interfere with performance on language tasks, nor with tasks that only require generation of images. Two imagery tasks (Picture Words and Letter Tracking) and two verbal tasks (Opposites and Sounds Tracking) were performed under three levels of interference: No, Low, and High Interference. A number of criterion measures were used as indices of interference: task errors, visual-monitoring errors, response time and difficulty ratings.

The following hypotheses were tested:

Hypothesis 1: For each task, the number of task errors obtained under No Interference will not differ from those obtained under Low Interference.

Hypothesis 2: Subjects will make significantly more total errors (task errors plus X-Checking errors) in the High Interference condition than in the other levels of interference.

Hypothesis 3: More total errors will be observed for the Letter Tracking task than for the other three tasks.

Hypothesis 4: Under the high interference condition, subjects will make more total errors in the Letter Tracking task than in any other task.

Method

Subjects.

Eighteen female and eighteen male high-school students served as subjects. They were randomly selected from a pool of volunteers in two high-schools. Thirty-two subjects attended a public school and the remaining four subjects were enrolled in a private school. Both schools serve an upper-middle class clientele.

The students ranged in age from 16 years, 5 months to 19 years, 3 months. Their median age was 17 years, 6 months. Their self-reported academic achievement, expressed in letter grades, ranged from C to A, with 19 students reporting grades in the C range and 15 students reporting in the B range.

Tasks, materials and instructions.

The tasks, materials and instructions for each of the experimental tasks are described below. All instructions and stimuli (i.e., word lists, sentences, letter names) were tape recorded and presented aurally to subjects. Each of the four experimental tasks had three sets of stimuli (e.g., three word lists for the Opposites task), designed to be equivalent stimuli.

Picture Words task. Subjects were instructed to generate visual images for words presented aurally via tape recorder. Lists of words were presented at a rate of one word every three seconds. For each word, subjects would attempt to conjure a visual image. They would say 'Yes' if they were able to conjure an image for the stimulus word. If unable to generate a visual image, they would say nothing and attempt to generate an image for the next stimulus word.

Four lists of stimulus words were created, a sample list for the familiarization trials and three experimental lists. The lists (see Appendix A) were composed of nouns equated for their imagery value and frequency ratings (Paivio et al., 1968). Only words that would presumably tap visual

visual imagery were selected. Words such as lemon and kiss that could tap other imagery modalities were not included.

The instructions for the Picture Words task were as follows:

> In this task, you will be asked to visualize, to make a mental picture for different words. For example, if I say 'house', can you visualize a house?... (Pause to allow for subject's response)... Can you describe the house you visualized?.... (Pause to allow for brief description)... You will hear a number of words, one at a time. After each word, you will have a few seconds to try to visualize or make a mental picture for that word. Once you have a mental picture say 'Yes'. Do not say yes until you have a mental picture for the word. If you cannot get a mental picture for a word, try the next one. Try to visualize each word, but don't worry if you cannot make a mental picture for all words. Remember, say 'Yes' when you get a mental picture for the word; if you can't get a mental picture, say nothing and try the next word.

Letter Tracking task. This task is an elaboration of an imagery task used by Brooks (1967). Four block letters (see Appendix B) were mounted on 7 X 21cms. cards. An asterisk in the bottom left corner of all letters indicated the starting point for the tracking task, and the arrow indicated the direction of the tracking. These cards were used to illustrate the task, which consisted of the subject tracking clockwise along the perimeter of the letter from corner to corner. At each corner the subject would have to verbally indicate its position (i.e., top, middle or bottom). For example, for the letter  the subject would say: "bottom, middle, middle, middle, middle, top, top, middle, middle, middle, middle, bottom." The experimental task required subjects to perform this task without looking at the card, from memory. Upon hearing the letter name, the subject would then proceed with the Letter Tracking task.

The letters E, H and S were selected as experimental stimuli because they appeared to be very similar to one another in respect to one critical feature: all three have twelve corner points.

The letter-tracking task was introduced with the following instructions:

> This task is called Letter Tracking. See these letters on these cards ...(pause, experimenter points to the four cards)...What you have to do is to start at the bottom left hand corner, at these points ...(pause, experimenter points to asterisks on cards) ..., and travel clockwise from corner to corner. At each corner you have to say whether that corner is at the top, middle or bottom positions. These corners are all in the bottom...(pause, experimenter points to bottom positions of the four letters)..., these corners are all in the top...(pause, experimenter points to top positions)..., and these are all in the middle positions...(pause, experimenter points to middle positions). For example, for the letter 'F', starting at this corner, you would say: 'bottom, top, top, middle, middle, middle, middle, middle, middle, middle, bottom'. Now you try it with the same letter...(pause, subject tracks letter 'F')...Are there any questions about what you have to do?...(pause)...Remember, always start at the bottom left, (experimenter points to asterisks), travel clockwise, and finish at the last corner before the starting point. Now, what you will have to do is to do the tracking without looking at the letter, from a mental picture of the letter.

Opposites task. Subjects were instructed to give an antonym for each word of a list presented aurally. Subjects were given 3 secs. to respond to each word. Four lists, one for familiarization and three for the experimental trials, were created, containing ten words varying in difficulty. The words comprising each list and the criteria for selection are presented in Appendix C.

The opposites task was introduced with the following instructions:

> This task is called Opposites. You will hear a word and you will give its opposite. For example, if you hear 'day', you would say 'night', or if you hear 'hostile' you could say 'friendly'. You will hear a number of words, one at a time. You will have a few seconds to say the opposite for each word. You have to respond before the next word is presented. If you can't think of an opposite in the alloted time, forget about that word and try to give an opposite for the next word you hear. Do not worry if you can't give an opposite for all words. Let's try it. Give me an opposite for: (practice list was presented).

Sound Tracking task. This task was designed as a verbal/auditory analog to the Letter Tracking task. Subjects were aurally presented with a simple sentence (i.e., "The bird made a nest in the tall tree") and were asked to say the first sound of each word of the sentence (e.g., th, b, m, a, n, i, th, t, t). Thus, like in the Letter Tracking task, subjects had to sequentially track items within a unit (sentence or letter) from memory.

Four sentences (a sample sentence and three experimental sentences) were created, attempting to equate them for number of syllables, sentence structure, and noun frequency.

The sample sentence was: "The cat has to sleep in the green box". The three experimental sentences were: (1)"The man goes to work in his new car", (2) "The girl rides to school on her red bike" and (3) "The bird made a nest in the tall tree".

Subjects were introduced to this task with the following instructions:

> This task is called sound tracking. You will hear a short sentence and then have to say the first sound of each word. For example, if you hear 'The cat has to sleep in the green box', you would say: 'th, c, h, t, s, i, th, g, b'. You see, I said the first sound for each of the words in the sentence. Now you try it. Say the first sound of the words in the sentence 'The cat has to sleep in the green box' ....(pause for subject's response)...Now let's try the same sentence again. Say the first sound of the words in the sentence 'The cat has to sleep in the green box'.

Interference task. The interference task, referred to as the 'X-Checking task', was computer generated (see Appendix D for computer program). This task consisted of either one of two stimuli ('X' or 'XX') displayed at one of four positions (12, 3, 6 or 9 o'clock) on a television screen. The order and location of stimuli presentation was randomized. Subjects were instructed to monitor the TV screen and to press the 'n' or 'm' keys on the computer keyboard in response to the appearance of 'X' or 'XX'. These keys were labeled with the numerals 1 and 2 respectively. The number of stimulus presentations and the duration of exposure for each stimulus could be varied across trials, although the duration of exposure could not be varied for stimuli within a trial. The computer program kept track of correct, incorrect or missed responses.

Subjects were introduced to this task with the following instructions:

> This task is called 'X-Checking'. You will see one or two Xs appear on the screen...(pause; experimenter activates the program)...See? You have to press this key (experimenter points to key with numeral 1 on it) when one X appears and this key (experimenter points to key with numeral 2 on it) when two X's appear. Use these two fingers (shows index and middle finger) to press the keys. Now you try it.

Levels of interference. There were three levels of interference. Under the No Interference condition, subjects remained seated in front of the TV monitor but it was cleared of any signals. Subjects were instructed to look at the empty screen while performing the tasks. The Low and High Interference conditions differed in the duration of the exposure of the simuli ('X' or 'XX'). The rates were selected on the basis of available data (Paivio, 1971, p. 344) suggesting that image generation for stimulus words requires about .6 to .75 seconds. In the Low Interference condition, the stimuli ('X' or 'XX') remained on the screen for about 2.8 seconds, whereas in the High condition the stimuli were displayed for about 1.4 secs. Under both conditions subjects had sufficient time to respond to the stimuli and generate an image. However, the Low condition could provide additional time to sustain, manipulate or inspect an image whereas the High condition afforded no such opportunities. Neither interference condition was expected to disrupt tasks that only require the generation of images (i.e., Picture Words) but the High condition should disrupt tasks where images need to be sustained so they can be manipulated or inspected (i.e., Letter Tracking).

Ratings of task difficulty. After each trial, subjects were asked to judge the difficulty of the task just performed. These judgment were based on a seven-point, Likert-type scale (1=very easy; 7=very difficult). To facilitate these judgments, a graphic representation of the scale, mounted on a 8 X 26cms. card, was in full view of subjects.

This rating procedure was explained to the subjects with the following instructions:

> You will be doing a number of different tasks. You will be asked to judge how easy or difficult you found each of them. If you find a task very easy, give it a one; if you find it very difficult, you will give it a seven. You can use a rating between one and seven if a task is neither very easy nor very difficult. You may find all tasks equally difficult or equally easy, or some may be easier than others. Feel free to use the entire range of numbers, from one to seven; at the same time, don't be concerned about how often you use a particular number as long as it is your true judgment. This pictorial representation (experimenter points to the card with graphic representation of the scale) will remain in front of you for your reference.

Procedure.

Subjects were tested individually and received all experimental treatments. After being welcomed to the experimental setting, subjects were told that this study was designed to investigate how people go about solving problems. A very brief description was given of each task. The experimenter then asked subjects to rate their overall academic achievement (expressed in letter grade) and to report their age.

They sat at a table in front of an Apple II (Plus) computer with a 14" black and white TV monitor, placed about .75m. from their eyes. The experimenter was seated to the right of the subject, so that he could program and activate the X-Checking task. Behind the subject, on a small table, two tape recorders were placed to give the tape recorded intructions. These tape recorders were also activated by the experimenter. The graphic representation of the rating scale was in full view of the subject, to the left of the keyboard.

The testing session consisted of familiarization and experimental trials. These are described below.

Familiarization trials. These trials were designed to familiarize the subjects with the experimental tasks and procedures and to obtain baseline measures on task performance and difficulty ratings.

Subjects were first introduced to the rating scale using the tape recorded instructions described above. They were then familiarized with the four experimental tasks. Each task was introduced with the tape recorded instructions. For the Picture Words and Opposites tasks, they received practice with the sample lists (see Appendices A and C). For the Letter and Sound Tracking tasks, two practice trials were given with the respective sample items and one practice trial with each of the experimental letters (see Appendix B) and sentences.

The sequence of task presentation and of stimuli within task was partially counterbalanced. Half the subjects were given the imagery tasks (Picture Words, Letter Tracking) first, followed by the two verbal/auditory tasks (Opposites, Sound Tracking). The other half of the subjects received the reverse sequence, with the language tasks first followed by the imagery tasks. In addition, the order of stimuli for the Letter and Sound Tracking task was also partially counterbalanced, using three sequences. These were: sequence one had E, H and S for Letter Tracking, and Sentences 1, 2 and 3 for Sound Tracking. Sequence two had letters S, E and H, and sentences 2, 3 and 1; sequence three had letters H, S and E, and sentences 3, 1 and 2. Thus, combining the two sequences for task presentation with the three sequences for stimuli-within-task, six sequences of presentations were created. Subjects were assigned to one of these six sequences using a sampling without replacement procedure.

For each familiarization trial, the experimenter recorded the subjects' responses (e.g., items to which they said 'yes' in the Picture Word task), the positions (top, middle or bottom) given in the Letter Tracking task, the antonyms given to stimuli words in Opposites task, and the sounds for the Sound Tracking task). The experimenter also recorded the response times for the Letter and Sound tracking tasks. Timing began immediately after the stimulus was presented and stopped when the subject stopped tracking the stimulus. The difficulty ratings given after each trial were also recorded.

After practice had been given with the four experimental tasks and each trial was rated for difficulty, subjects were asked to rate the difficulty of these four tasks.

In the last phase of the familiarization procedure, the subjects were introduced to the interference task (X-Checking task) using the instructions described above.

The experimenter set the rate (i.e., 1.4 or 2.4 secs. per stimuli) and the number of stimuli (i.e., 22 or 11) for each trial and started them by pressing the 'Return' key on the keyboard. The two rates were presented alternately. Practice stopped when subjects attained two consecutive trials with fewer than two errors in each trial. This completed the familiarization portion of the experiment.

Experimental trials. The experimental trials followed immediately after the familiarization procedures. In general terms, subjects had to do the four experimental tasks either by themselves (under No Interference condition) or concurrently (under Low and High Interference conditions) with the X-Checking task.

The sequences of task presentation and of stimuli within task were partially counterbalanced according to the plan shown in Table 1.

These sequences partially counterbalanced order of task presentation and order of stimuli presentation within task. The three levels of interference for each task were presented consecutively, with the sequence of presentation (e.g., Low, No, High Interference) randomized for each task and for each subject. Subjects were assigned to one of the four sequences using a sampling without replacement procedure.

Following the familiarization trials, subjects were introduced to the experimental trials with the following instructions:

> You have had practice doing the four tasks (Opposites, Picture Words, Sound Tracking and Letter Tracking). You will be doing them again, but this time either by themselves or together with the X-Checking task. For example, you will do the Opposites task by itself or with the X-Checking task. I will first get you started with the X-Checking task and after a few seconds you will hear a list of words and you have to say their opposites. Let's have a trial run. I'll start you on the X-Checking task and then you will hear the first word. Give its opposite but keep on pressing the keys for the one or two Xs. Try to make as few errors as possible on the X-Checking task. Let's try it. Ready?

The procedure was similar for all tasks. The stimuli (e.g., lists, sentences, letter names) were on tape. For each trial, the experimenter activated the tape recorder to present the stimuli. A tone cued the experimenter to start the X-Checking task for the No and High Interference trials. Approximately five seconds later, the experimental stimuli

Table 1

Counterbalancing plan for Experiment 1

	Task order (stimuli order)			
	First	Second	Third	Fourth
Sequence 1:	PW (3,2,1)	LT (E,H,S)	Op.(2,3,1)	ST (1,3,2)
Sequence 2:	ST (3,2,1)	PW (1,2,3)	LT (H,S,E)	Op.(1,3,2)
Sequence 3:	Op.(3,1,2)	ST (1,2,3)	PW (2,3,1)	LT (E,S,H)
Sequence 4:	LT (S,E,H)	Op.(1,2,3)	ST (3,2,1)	PW (3,1,2)

Note. PW=Picture words; LT=Letter Tracking; Op.=Opposites; ST= Sound Tracking. The numbers (1, 2 or 3) refer to task stimuli, such as sentence #1 or list #2. The letters (E, H and S) refer to stimuli letters for Letter Tracking.

(e.g., words for Opposites task) were resented. Under the No Interference conditions, subjects would perform these tasks by themselves, as they did during the familiarization trials. For the Low and High Interference conditions, subjects performed each of the experimental tasks concurrently with the X-Checking task.

Each of the four experimental tasks was re-introduced with a brief set of instructions. The picture words task was introduced as follows:

> Remember the task where you had to generate mental pictures for words. You will hear words and you will try to generate mental pictures for them. Say "Yes" when and if you have a mental picture for each word. You will be doing this task by itself or together with the X-checking task. I'll let you know beforehand if you are doing both or the mental pictures by itself. Ready?

The experimental trials for the Letter Tracking task were introduced with the following instructions:

> Now we will be doing the Letter Tracking task again. Remember to always start here (..pause, experimenter points to the asterisks on the cards...) and end at this positions (...pause, experimenter points). Go clockwise from corner to corner, saying whether it is a 'top', 'middle' or 'botton' position. You will be doing this task by itself or together with the X-Checking task. I'll let you know beforehand whether you are doing both or the Letter Tracking task by itself. Ready?

Prior to each of the three trials, subjects were exposed to the four cards for 4 seconds. They were told whether the upcoming trial consisted of concurrent tasks and then the stimulus was introduced with "Track the letter ....."

The experimental trials for the Opposites task were introduced with the following instructions:

> Now we will do the Opposites task. Like before, you will hear a word and you have to say its opposite. If you can't do it in the alloted time, try the next word. You will be doing this task by itself or together with the X-Checking task. I'll let you know beforehand if you are doing both or the Opposites task by itself. Are you ready?

The following instructions introduced the experimental trials for the Sound Tracking task:

> Now we will do the Sound Tracking task. Remember that you have to say the first sound of each of the words in a sentence. You will be doing this task by itself or together with the X-Checking task. I'll let you now beforehand if you are doing both or the Sound Tracking by itself. Are you ready?

The experimenter recorded the subjects' responses as described in the familiarization procedure. At the end of each trial the difficulty rating was recorded, as well as the number of errors made on the X-Checking task during the Low and High levels of Interference.

After all experimental tasks were completed, subjects were asked to generate and sustain an image of their chosing for 5 seconds under two conditions: No and High Interference. After each of these, they were asked to rate the ease or difficulty of the task using the above mentioned rating scale.

Results

As described in the Procedure section, each of the four experimental tasks had three sets of stimuli. For the purposes of this study, these sets (e.g., three stimuli lists for the Opposites task) were presumed to be equivalent to each other. This assumption was supported by empirical data for the stimuli sets for the Picture-Words and Opposites task (see Appendices A and C). Data from the familiarization trials revealed that the stimuli sets for the other two tasks can also be considered to be equivalent. The mean numbers of tracking errors for each of the three stimuli letters ('E', 'H' and 'S') of the Letter Tracking task did not differ significantly, as indicated by a one-way repeated measures Anova (F(2,70)=1.57, p=.21). Similarly, no significant differences were found between the number of sound-tracking errors made for each of the three sentences of the Sound-Tracking task, with F(2,70)=2.63, p=.07. These findings are not central to the main questions of interest, but support the assumption of stimuli equivalency. Failure to satisfy this assumption could confound the interpretation of the results.

The main purpose of this study was to determine whether the X-Checking task would disrupt performance on the Letter Tracking task more than on the others. A number of criterion measures were used as indices of interference. They were: (a) task errors (e.g., subject gives an incorrect antonym to Opposites task), (b) X-checking errors made in the Low and

High Interference conditions (e.g, subject presses key with numeral '1' when two Xs are displayed), (c)total errors, derived by adding task and X-Checking errors, (d)difficulty ratings given to the tasks under the three interference conditions, and (e)tracking time required for the letters and sentences in the Letter-Tracking and Sound Tracking tasks. Results for each of these criterion measures are discussed below. Data obtained during the familiarization trials are presented in Appendix E.

The rate of stimuli presentation in the X-Checking task was twice as fast for the High vs. than Low Interference conditions, although the duration of trials was the same. This meant that twice as many stimuli were presented in the High vs. Low Interference, and therefore subjects had twice as many opportunities for making errors in the High condition. For this reason, raw scores were considered inappropriate for comparing performances and were therefore converted to percentage scores. For the same reasons (i.e., differences in the total possible scores), task errors were also converted to percentage scores.

Task errors. As noted above, task errors were designated as one measure of interference. For the Picture-Words task, task errors were defined as the subjects' inability to generate images for stimuli words, evidenced by the failure to say 'Yes' to one or more stimuli words. Thus, in this task, no response was scored as an error. Task errors in the Letter-Tracking task were defined as subjects saying one or more wrong corner position. For example, the right responses for the letter S were "bottom, middle, middle, middle, middle, top, top, middle, middle, middle, middle, bottom". An error was any substitution, omission or addition to that sequence. For the Sound-Tracking task, task errors were determined by counting the total number of omissions, substitutions or additions made to the correct sequence of initial sounds for the words of each sentence. Task errors on the Opposites task were incorrect antonyms for the stimuli words or failure to respond. The Book of synonyms and antonyms (Urdang, 1982) was used as the criteria for judging reponses.

Means and standard deviations of percentage of Task errors under the three Interference conditions are presented in Table 2. Figure 1 shows the mean percentage of task errors for the four experimental tasks under the three levels of Interference. Although the four experimental tasks differed in their baselines of percentage Task- errors, they are considered to be comparable in difficulty, as demonstrated by subjects' difficulty ratings (see section on 'Difficulty Ratings' below).

The question of interest related to the effect of the X-Checking task on the concurrent experimental tasks. A Task by Interference effect was expected. Visual inspection of Figure 1 suggests that the interference (X-Checking) task had a negligible effect on task performance for three of the experimental tasks, but appeared to have a substantial

Table 2. Means and Standard Deviations ( ) for Criterion Measures on the Experimental Tasks under No, Low and Interference.

		Experimental Tasks			
	Levels of Interf.	Picture Words	Letter Tracking	Opposites	Sound Tracking
% Task Errors					
	No	24.7	3.9	19.7	6.5
		(15.4)	(12.7)	(12.3)	(10.1)
	Low	24.4	12.7	23.1	5.3
		(15.6)	(24.4)	(10.4)	(9.8)
	High	24.7	22.5	25.3	6.5
		(16.8)	(21.0)	(11.8)	(10.7)
% X-Checking Errors					
	Low	1.7	13.6	4.5	6.4
		(4.2)	(15.3)	(5.6)	(8.7)
	High	5.6	32.7	9.9	16.1
		(5.9)	(13.1)	(8.4)	(13.0)
Difficulty ratings					
	No	2.4	2.0	2.3	2.6
		(1.3)	(1.1)	(1.0)	(1.3)
	Low	2.7	4.6	2.8	3.4
		(1.2)	(1.5)	(1.1)	(1.6)
	High	2.9	5.6	3.2	3.9
		(1.2)	(1.3)	(1.2)	(1.5)
Tracking time (secs.)					
	No		10.0		8.9
			(3.3)		(3.5)
	Low		17.6		10.4
			(4.7)		(3.0)
	High		21.0		10.9
			(4.4)		(2.7)

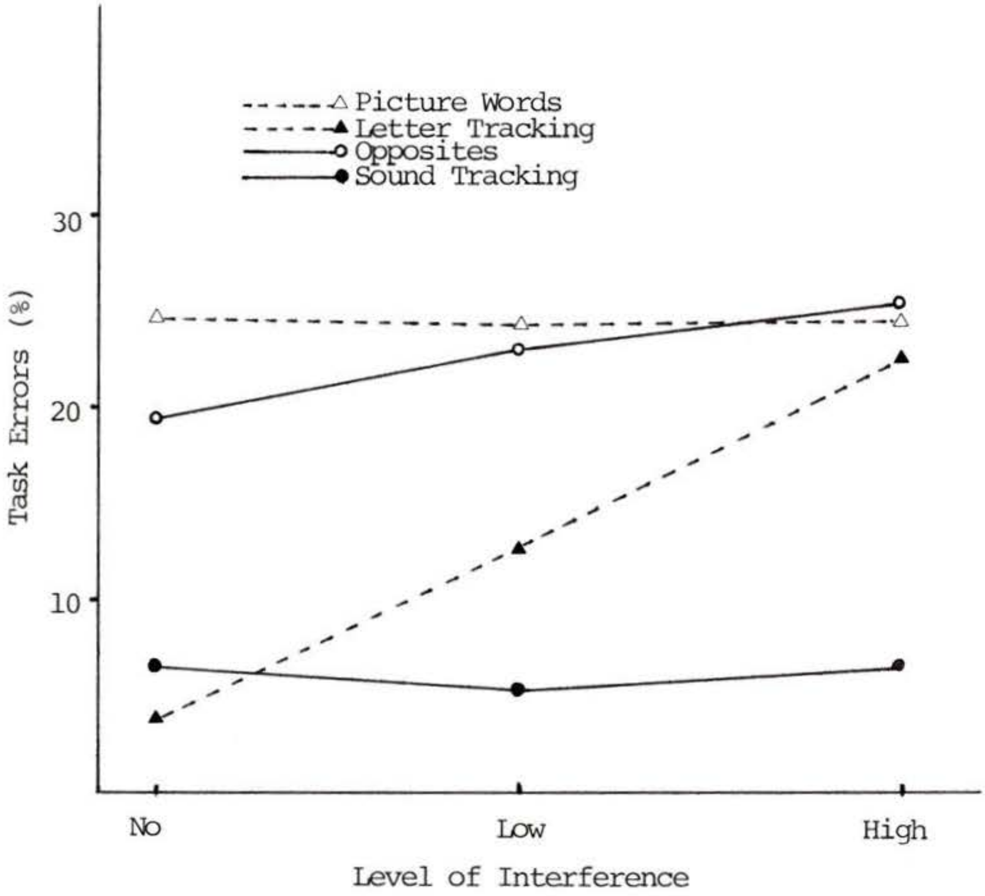

Figure 1. Mean Percentages of Task Errors for the Experimental Tasks under No, Low and High Interference.

effect on task performance for the Letter-Tracking task.

A four (Tasks) by three (levels of Interference) repeated measures Anova was performed on these data. A summary of this analysis is presented in Table 3. The results of multivariate test of significance for these and the other dependent measures are shown in Appendix F. The Anova revealed a significant Tasks by Interference effect, with $F(6,210)= 6.58$, $p<.01$. Tests for simple main effects of the Task by Interference interaction indicated that, as suggested by Figure 1, this overall interaction resulted primarily from an interaction between Letter Tracking and Interference. This interaction was highly significant, with $F(2,70)= 13.21$, $p<.001$. There was also a significant Opposites by Interference interaction, with $F(2,70)= 4.02$, $p<.05$. The other two tasks, Picture Words and Sound Tracking, did not show significant simple main effects with $F[2,70]= 0.11$, $p>.9$ and $F[2,70]=.40$, $p>.6$ respectively.

Hypothesis One predicted that there would be no significant difference in the number of task errors for each of the experimental tasks under No and Low Interference. This was evidently true for the Picture Words and Sound Tracking tasks. Inspection of Table 2 and Figure 1 shows that the mean percentage errors obtained under No And Low interference were very similar for these two tasks. A planned comparison showed that the percentage of task errors for the Opposites task were not significantly different

Table 3: Summary Analysis of Variance on Task Errors for Factors: Tasks and Interference.

Source	df	MS	F	p
Within Subjects				
Tasks	3	8102.12	23.36	<.001
Error	105	346.82		
Interference	2	1310.01	11.47	<.001
Error	70	114.19		
Task X Interference	6	693.21	6.58	<.001
Error	210	105.32		

under No and Low Interference (F[1,70]= 1.75, p>.05). However, significantly more task errors were obtained in the Low vs. No Interference for the Letter-Tracking task, with F(1,70)=12.19, p<.01. Thus, Hypothesis One was partially supported.

These results indicate that the X-Checking task produced significant deterioration in the performance on the Letter Tracking task, as evidenced in task errors. A statistically significant but less robust effect was obtained for the Opposites task. Interference effects were not obtained for Picture Words and Sound Tracking tasks. Therefore, these data provide initial support for a differential interference effect of the X-Checking task.

X-Checking errors. Under the Low and High interference conditions, subjects could make task errors (described above) as well as errors in the X-Checking task. The latter could be made by pressing the wrong key (e.g., pressing the key with the numeral 2 when one X was displayed on the monitor), or by neglecting to respond to the stimuli. These X-checking errors were taken as another index of interference.

As noted above, the X-Checking errors obtained for each task under Low and High Intereference were converted to percentage scores. Means and standard deviations are reported in Table 2. The mean percentages of X-Checking errors are presented in Figure 2.

Visual inspection of Figure 2 suggests that more

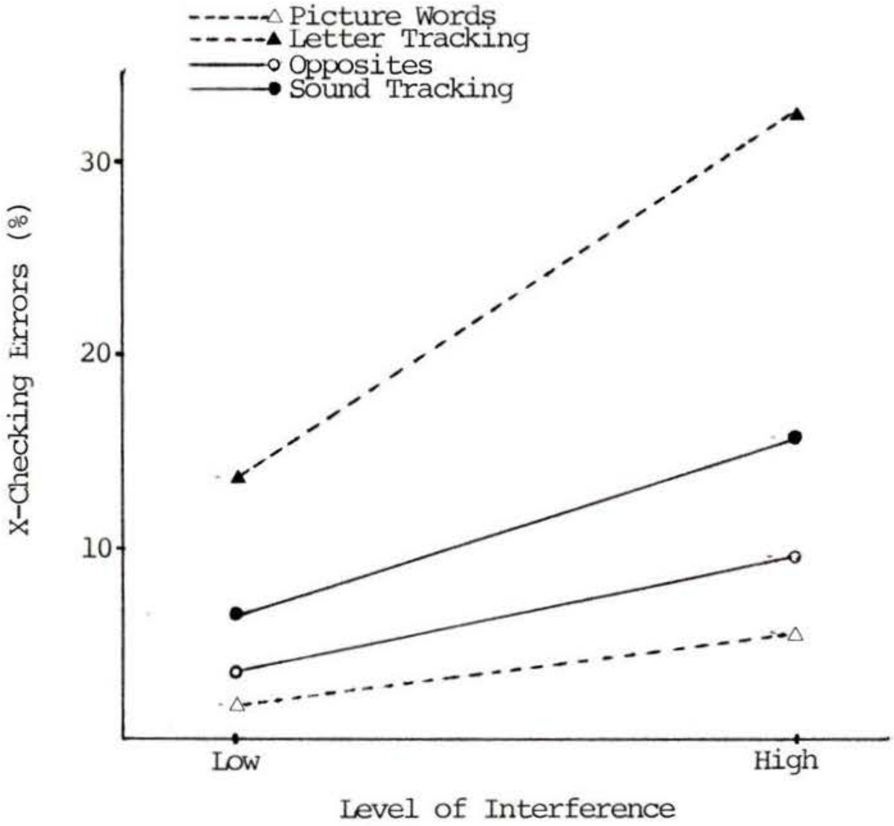

Figure 2. Mean Percentages of X-Checking Errors for the Experimental Tasks under No and High Interference.

X-checking errors were made under High than Low Interference, but that this effect was more pronounced for the Letter Tracking than for the three other tasks. A two (High and Low Interference) by four (Tasks) repeated measures Anova yielded a significant Task by Interference interaction, with F(3,105)=14.06= p <.01. Table 4 summarizes the results of this analysis. Tests for the simple main effects of the interaction revealed significant Task by Interference interactions for Letter Tracking (F[1,35]= 56.48, p<.001), Sound Tracking (F[1,35]= 14.63, p<.001) and Opposites (F[1,35]= 4.59, p<.05). The Picture Words by Interference interaction was not significant, with F(1,35)= 2.29, p>.05.

As expected, the greatest number of X-Checking errors was obtained in the Letter Tracking task, with a substantial increment in errors in the High vs. Low Interference. Contrary to expectations, a similar but less pronounced pattern of results was obtained for two other tasks (Sound Tracking and Opposites). No effect was obtained for Picture Words. As with task errors, these results were generally consistent with the expectation that the X-Checking task would be most disruptive to performance in Letter Tracking.

Total errors. Recall that subjects performed the experimental tasks concurrently with the X-Checking task in the two Interference conditions. Thus, subjects could make errors in either or both tasks. It is conceivable that subjects could devote their attention to one task and ignore

Table 4: Summary Analysis of Variance on X-Checking Errors for Factors: Tasks and Interference.

Source	df	MS	F	p
Within Subjects				
Tasks	3	5171.11	47.84	<.001
Error	105	108.07		
Interference	1	6537.93	56.23	<.001
Error	35	116.25		
Tasks X Interference	3	843.45	14.06	<.001
Error	105	59.98		

the concurrent one. In such cases, consideration of errors from one source alone would not provide an accurate picture of the interference effect. A more accurate account of the overall interference effect can be made by deriving a score that combines the sources of errors (X-checking and task errors). Such scores, called Total errors, were computed by adding the percentage Task errors and X-Checking errors obtained for each task under Low and High Interference. Although the underlying metric of these two types of scores may not be equivalent, their summation is a meaningful representation of the overall interference effect, much like the summation of marks on different courses represents academic achievement or the combination of different physiological measures provides an index of physical fitness. In this study the Total Errors score represents the overall interference effect. These data are presented in Table 2 and in Figure 3.

The summary of a two (Low and High Interference) by four (tasks) repeated measures Anova is presented in Table 5. This analysis revealed a significant Task by Interference interaction, with $F(3,105) = 9.85$, $p < .001$. Test for simple main effects of the interaction revealed that the Letter and Sound Tracking tasks contribiuted to this interaction. Total errors obtained under Low and High Interference did not differ for Picture Words and Opposites ($F[1,35] = 1.12$, $p > .05$ and $F[1,35] = 3.87$, $p > .05$ respectively), but did differ for the Letter and Sound Tracking task ($F[1,35] = 54.73$,

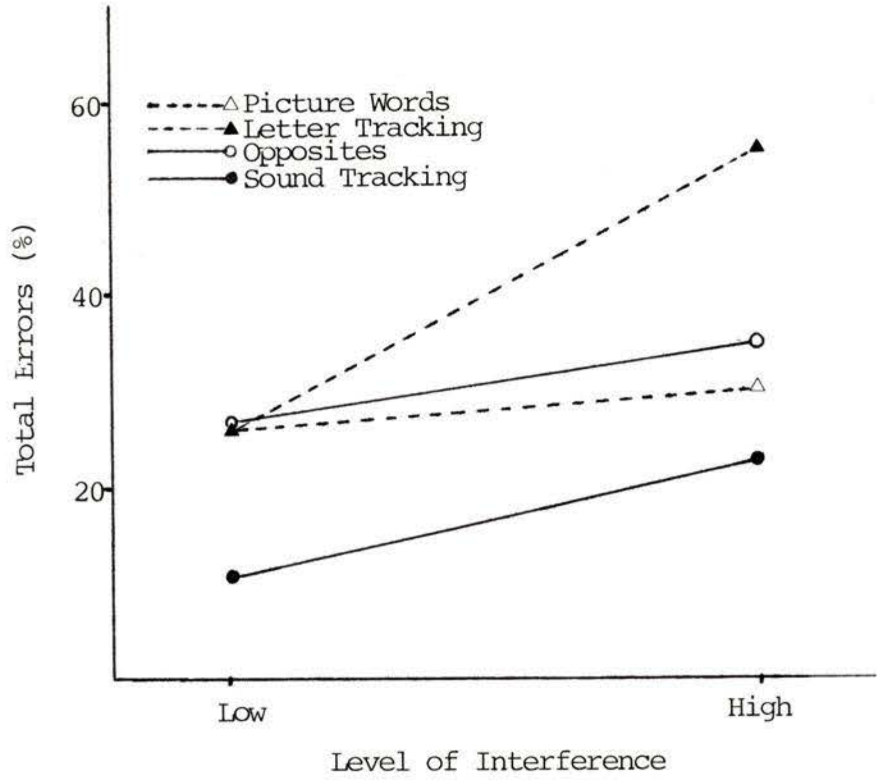

Figure 3. Total Errors (%) Obtained in the Experimental Tasks Under Low and High Interference.

Table 5: Summary Analysis of Variance on Total Errors for Factors: Tasks and Interference.

Source	df	MS	F	p
Within Subjects				
Tasks	3	6850.16	17.66	<.001
Error	105	387.90		
Interference	1	11969.15	43.81	<.001
Error	35	273.19		
Tasks X Interference	3	2169.83	9.85	<.001
Error	105	220.14		

$p<.001$ and $F[1,35]= 7.90$, $p<.01$ respectively).

The main effect of Interference was significant, with more Total errors obtained under High vs. Low interference ($F[1,35]= 43.8$, $p<.001$). These results support Hypothesis Two.

The third hypothesis predicted that more Total errors would be made in the Letter Tracking task than in all others. A planned comparison was undertaken. Collapsing across levels of interference, significantly more Total errors were made in the Letter-tracking task than in the Opposites task, which showed the second highest rate of errors ($F(1,35)=6.96$, $p<.05$). Thus, hypothesis three was supported.

Hypothesis four stated that in the High Interference condition, subjects will make more errors in the Letter Tracking task than in all others. Here again, the errors in the Letter tracking task were compared with those of the task (Opposites) with the second highest number of errors. Significantly more errors were obtained for the letter tracking task, with $F(1,35)=16.7$, $p<.01$. The fourth hypothesis was also supported.

These data on Total errors are consistent with task and X-Checking errors. The X-checking task disrupted performance on the Letter Tracking task consistently and substantially relative to the other tasks. An interference effect was also obtained for the Sound Tracking task, although less pronounced. No interference effect was found for the Picture

Words and Opposites tasks.

Difficulty ratings. Another index of an interference effect was difficulty ratings. After each trial, subjects rated the task for difficulty. The mean ratings and their standard deviations are presented in Table 2. These data are plotted in Figure 4.

Notice that these subjective ratings reflect the patterns of findings obtained on the dependent measures described above. The Letter Tracking task was perceived as becoming increasingly difficult across levels of interference, reflecting the actual increase in Letter Tracking and X-checking errors. A similar but less pronounced pattern of increasing difficulty was reported for the Sound Tracking task.

The results of a three (levels of Interference) by four (Tasks) repeated measures Anova performed on these data are summarized in Table 6. A significant Task by Interference interaction was obtained, with $F(6,210)=25.32$, $p <.01$.

Under No interference the four tasks did not differ in their rated difficulty ($F[3,105]= 1.75$, $p>.05$). However, as evident by inspection of Figure 4 and consistent with data from Total, Task and X-checking errors, the Letter Tracking task became increasingly difficult relative to the other tasks under Low and High Interference. Thus, the specific interference effect of X-checking on the Letter Tracking task is supported by objective data (e.g, task errors) but also by subjective ratings of task difficulty.

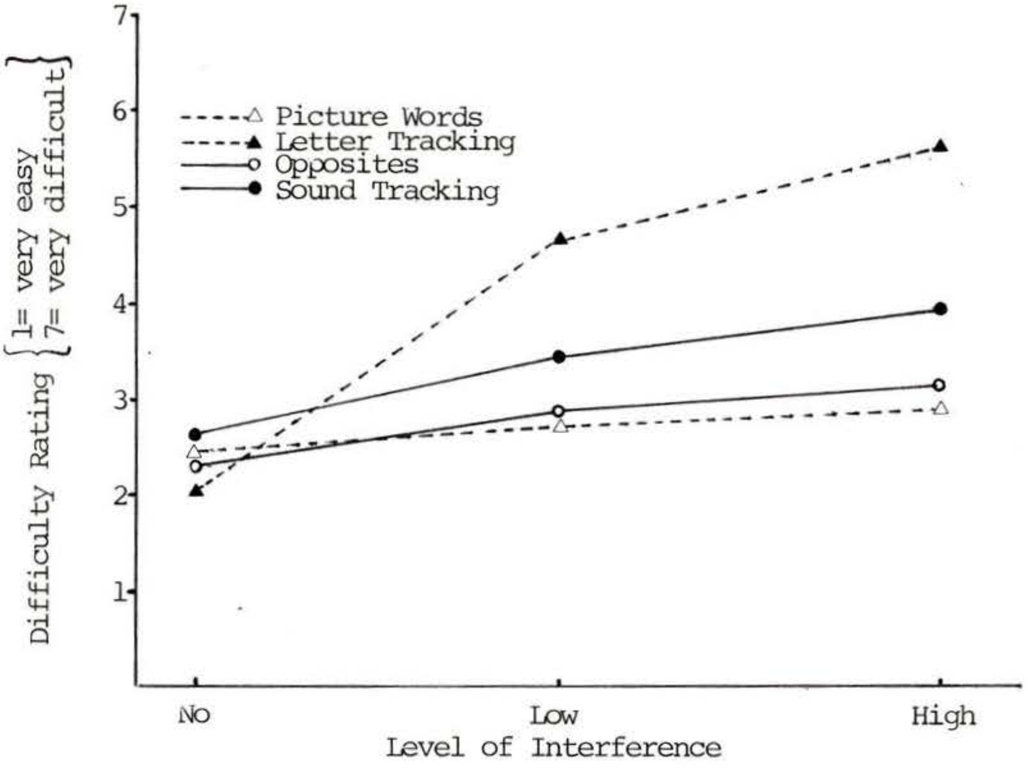

Figure 4. Difficulty Ratings for the Experimental Tasks Under No, Low and High Interference.

Table 6. Summary Analysis of Variance on Difficulty Ratings for Factors: Tasks and Interference.

Source	df	MS	F	p
Within Subjects				
Tasks	3	44.49	22.13	<.001
Error	105	2.01		
Interference	2	91.15	118.79	<.001
Error	70			
Task X Interference	6	19.07	25.32	<.001
Error	210	.75		

Tracking time for letters and sounds. Whereas the response time for the Opposites and Picture words task was fixed, subjects were allowed to take as much time as needed for the Letter and Sound Tracking tasks. Thus, response time can then be used as yet another index of interference. Mean tracking times and standard deviations for these two tasks under the three levels of interference are shown in Table 2. These tracking times are plotted in Figure 5.

Visual inspection of Figure 5 reveals that whereas the amount of time required to track the initial sounds of words in the Sound Tracking task was relatively unaffected by Low and High Interference, tracking time for the Letter Tracking task was affected by Interference. A two (Tasks) by three (levels of Interference) Anova yielded a significant Task by Interference interaction, with $F(2,70)=49.26$, $p <.01$. Table 7 summarizes the results of this analysis. Tests for simple main effects of this interaction did show a Sound Tracking by Interference interaction ($F[1,70]=13.24$, $p<.001$). Further comparisons showed that subjects took significantly longer to do the Sound Tracking task under Low vs. No Interference ($F[1,70]=6.34$, $p<.05$), but no significant difference was found between Low and High Interference ($F[1,70]= .68$, $p>.10$).

As reported in Table 7, the Task effect was highly significant, with $F(1,35)= 87.47$, $p<.001$, indicating that the amount of time required for the Letter Tracking task was substantially longer than for Sound Tracking, even though

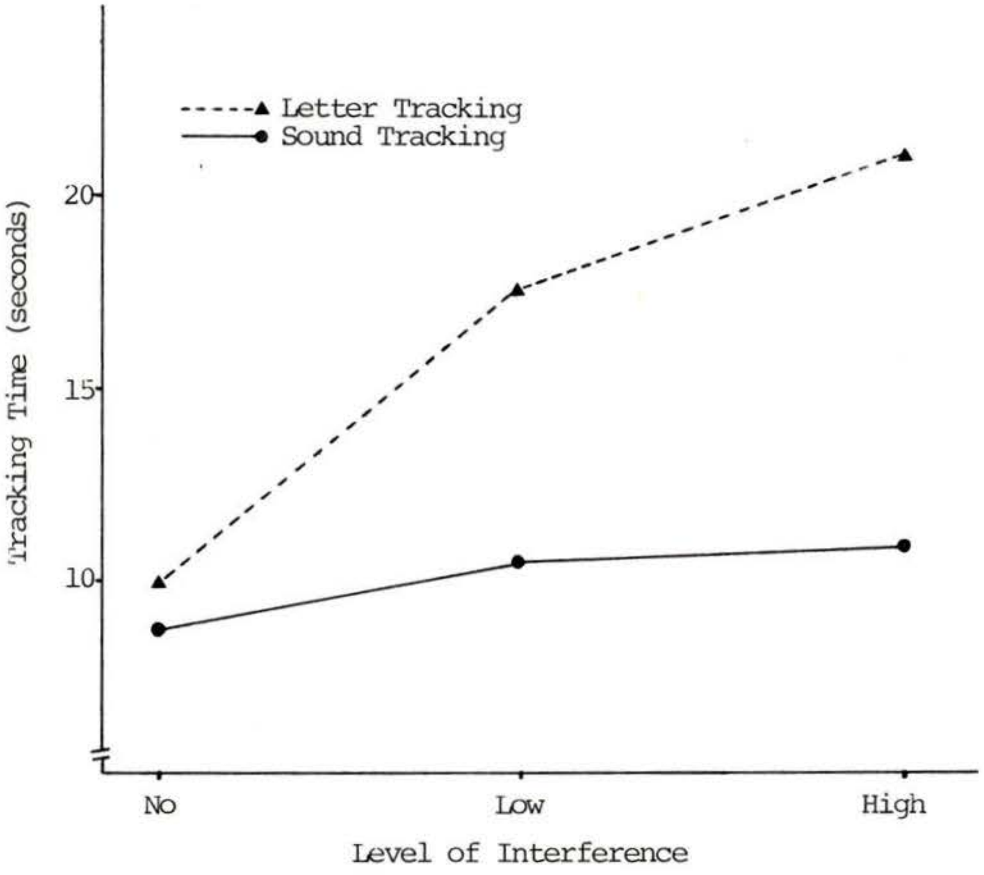

Figure 5. Tracking Time (secs.) for Letter and Sound Tracking Tasks under No, Low and High Interference.

Table 7: Summary Analysis of Variance on Tracking Time for Factors: Tasks and Interference.

Source	df	MS	F	p
Within Subjects				
Tasks	1	2012.39	87.47	<.001
Error	35	23.00		
Interference	2	816.01	117.54	<.001
Error	70	6.94		
Tasks X Interference	2	376.41	49.26	<.001
Error	70	7.64		

there was no difference in tracking times between these tasks in No Interference (F[1,35]=.92, p>.05).

These results for tracking time are consistent with those reported above. They show that the X-Checking task interferes more with performance on Letter Tracking than on the other tasks.

Recall that the last task performed by subjects consisted of generating an image of their choice, maintaining it for 5 secs., and then generating and sustaining it again concurrently with the X-Checking task under High Interference. Subjects were then asked to rate the difficulty of sustaining that image under those two conditions. The mean difficulty rating under No Interference was 1.6 and 3.0 under High Interfrence. A t-test revealed that these means differed significantly from each other, with t(35)=5.89, p<.01.

Discussion. These results indicate that the X-Checking task had a small and inconsistent detrimental effect on the performance of Picture Words, Opposites and Sound Tracking, which can best be attributed to the added difficulty of performing concurrent tasks. Above and beyond this trend, the above results consistently demonstrated that the X-Checking task disrupted performance on the Letter Tracking task more than it did on the other three tasks. As expected, it selectively interfered with performance on the Letter Tracking task. This finding is robust, and corroborated by all the criterion measures employed. The interpretation given to these findings assumes that the Letter Tracking task relies on the sustaining of a visual image of the stimulus letters, a process that is disrupted by the X-checking task. The claim is that the X-checking task, by actively engaging the visual processing channel, prevents the simultaneous sustaining of a visual image. Other tasks were not similarly disrupted because their execution does not rely on the sustainment of a visual image. The other imagery task, Picture Words, was not disrupted since it only required the generation of images.

This interpretation is supported by data and observations from this study. Recall that in the last task of the experiment, subjects reported it became significantly more difficult to sustain an image under High Interference. Furthermore, subjects spontaneously reported during the Letter Tracking task (usually under High Interference) that "I lost it". When questioned, they said they had lost the image.

An alternate interpretation is that these results are an artifact of task demands. The most likely interpretation along this vein would suggest that more errors were obtained in the Letter Tracking task because if one momentarily lost one's place in the tracking sequence, the last response given (e.g., middle) would not provide a helpful cue to relocate one's position. This is the case because, for instance, there are more than one "middle" positions. The situation is different for the Sound Tracking task, where each sound provides a better cue for retrieving one's position in the sequence were one to lose one's place. If this analysis were correct, we should find that those subjects who made no tracking errors in the Letter Tracking task would also make fewer X-checking errors and tracking time should decrease. This was not the case. Seven subjects made no Letter-Tracking errors under High Interference. Their mean tracking time was 19.8 secs. and their mean rate of errors was 25%, both similar to the means for the whole group (21.0 secs. and 32.7% respectively). This suggests that even those subjects who made no task errors found their performance disrupted in terms of X-checking errors and tracking time.

The data obtained in this first experiment revealed that the X-Checking task substantially and consistently disrupted performance on the Letter Tracking task, giving support to the claim that the X-Checking task interferes with the sustainment of visual images. This finding then provides a basis for using the X-Checking procedure as a way determining the effect of imagery interference on task performance. This approach was pursued in the second experiment, in which the role of visual imagery in divergent thinking was investigated.

Experiment II

The second experiment was designed to determine whether visual imagery contributes to performance on divergent thinking tasks.

Subjects were presented with concrete or abstract questions designed to elicit divergent thinking. They responded to these questions under two conditions: No Interference (question presented by itself) and High Interference (question presented concurrently with X-Checking task). Half the subjects were instructed to use visual imagery, whereas the other subjects received no imagery instructions. In addition, a test of habitual use of imagery was administered to determine whether scores on this test correlate with effectiveness of instructions and with task performance.

A three-factor mixed design was used, with Questions (Concrete/Abstract) and Instructions (Imagery/No-imagery) as between-subject factors, and with imagery Interference (with and without concurrent X-Checking task) as the within-subject factor.

In general, consistent with Kaufmann's (1980) analysis, it was expected that imagery would play a greater role in the flexiblity than the fluency aspects of divergent thinking but only for concrete tasks. Imagery was not expected to play a role in abstract divergent thinking tasks. Imagery instructions were expected to improve flexibility scores only for Concrete Questions, and only in the No Interference condition. Because they are in contradiction to task demands, Imagery Instructions should have a negative effect on performance on Abstract Questions, and on Concrete Questions under High interference. A positive correlation was expected between scores on the imagery test and flexibility scores for concrete tasks under No Interference.

The following hypotheses were tested:

Hypothesis 1: Fluency scores for Concrete Questions will not differ in the No and High interference conditions.

Hypothesis 2: Subjects responding to Abstract Questions without Imagery Instructions will attain higher Fluency scores than their counterparts who received instructions.

Hypothesis 3: Subjects without Imagery Instructions responding to Concrete Questions in the High Interference condition will attain higher Fluency scores than their instructed counterparts.

Hypothesis 4: Fluency scores of subjects in the Abstract, No Instructions group will not be affected by Interference.

Hypothesis 5: Subjects responding to Concrete Questions will attain higher Flexibility scores in the No than the High Interference conditions.

Hypothesis 6:For Concrete Questions the Imagery instructions group will obtain higher flexibilty scores than the No Instructions group under No Interference, but the opposite effect is expected in High Interference.

Hypothesis 7: Higher Flexibility scores will be obtained for Abstract Questions by the non-instructed than the imagery instructed group.

Hypothesis 8: Interference will have no effect on the performance of the Abstract, Non-instructed group.

Hypothesis 9: More X-Checking errors will be made for the Concrete than the Abstract questions.

Hypothesis 10: For Concrete questions under No Interference, low imagers who were given imagery instructions will attain higher scores than their non-instructed counterparts.

Hypothesis 11: A positive correlation will be obtained between scores on the imagery questionnaire and Flexibility scores of subjects in the Concrete, No-instructions group under the No Interference condition.

Method

Subjects.

The subjects were 40 male and 40 female high-school students. They were randomly selected from a pool of volunteers from three high-schools. Seventy-two students attended two public schools and eight were enrolled in a private school. These schools serve a middle and upper middle class clientele.

The subjects ranged in age from 16 years, 2 months to 19 years, 3 months. Their median age was 17 years, 9 months. Their academic achievement (self reported), expressed in letter grade, ranged from A to C-, with 42.8% of the students reporting achievement in the C range, and 46.3 in the B range.

Tasks, materials and instructions. The materials for each of the experimental tasks are described below.

Divergent thinking tasks. Two types of questions, Concrete and Abstract, served as divergent thinking tasks. These questions were alike in that they were open ended, allowing many possible responses.

The Concrete questions were adapted from the 'Uses' test (e.g., Give as many uses for a tin can as you can think), which are part of tests of creativity and divergent thinking tests (Guilford, 1967; Torrance, 1966). Three concrete divergent thinking questions were used, one as a practice item and two as experimental items. The practice question was: "Give me as many uses as you can think of for a metal coat hanger". The two experimental items were: (1) "Give me as many uses as you can think of for a brick" and (2) "Give me as many uses as you can think of for a cardboard-box".

The Abstract questions were created by the experimenter. Based on pilot trials, they were selected because they generated numerous responses and were judged by the experimenter to require more abstract thinking than the Concrete questions. This judgment was made on the basis of perceived abstractness of the nouns in the sentences, and the relationship between the elements of the sentence being more abstract than in the concrete questions. Validation of the abstractness of these questions is presented below. The practice question was: "Give me as many reasons as you can think why health is important to people and society". The two experimental questions were: (1)"How do weather and climate affect people and society? Give me as many effects as you can think of", and (2)"How do technology and machines affect people and society? Give me as many effects as you can think of."

The concrete/abstract distinction was validated by the ratings of experienced high-school teachers. These teachers rated the abstract questions as requiring more abstract thinking than the concrete questions. These questions were also rated for difficulty. These ratings are presented in Appendix G.

The following tape-recorded instructions were used to introduce the divergent thinking questions:

> This is a study of divergent thinking. Divergent thinking is the ability to give many different solutions to a problem or question. You will be asked two questions. You have to try to give as many and as many different kinds of answers as you can. For example, if I asked you why people live in cities, you could say because there are lots of movies, lots of places to shop, many restaurants or theatres to chose from, and so on. These are all good answers but they are all of the same kind: amenities found in a city. Can you think of different reasons why people live in cities? (...pause for subject's response...). Yes, they also live in cities because they can get work, they need specific medical attention, are attending university, or were simply born there. All these are different reasons why people live in cities. For the questions you will be asked, try to give as many responses and as many different

> kinds of responses as you can think of. Let's try an example.

Imagery interference. The X-Checking task, developed for and tested in the first study (for details, see Materials section of Experiment I), was used in this second study as a procedure for interfering with the use of imagery. Only the High level of Interference was used in the second study.

Under No Interference, subjects responded to a question by itself. In the High Interference condition, subjects responded to a question while simultaneously performing the X-Checking task.

Imagery instructions. Subjects who received imagery instructions were given the following tape-recorded instructions:

> I would like you to try to use mental pictures when you are thinking. People often use mental pictures to solve problems or to think about things. Try to form mental images of what you are thinking to help you with the questions I will ask you.

Subjects in the Imagery Instructions groups were reminded three times during the experimental tasks to use imagery.

Imagery questionnaire. This questionnaire was composed of those items of the Individual Differences Questionnaire (Paivio, 1971) that, according to Paivio and Harshman (1983), tap the habitual use of imagery. The questionnaire appears in Appendix H.

Procedure.

Two male experimenters conducted the study. All subjects were tested individually. Using a random sampling without-replacement procedure, subjects were assigned to one of the four conditions: Concrete Questions without Imagery Instructions, Concrete Questions with Imagery Instructions, and Abstract Questions with and without Imagery Instructions. In all four conditions, subjects responded to these questions under No and High Interference.

The order of presentation of the Interference trial was counterbalanced so that half the subjects received the Interference trial first. The order of presentation of the questions (e.g., question 2 presented first, followed by question 1) was randomly determined for each subject.

Subjects were seated at a table in front of an Apple II computer with a 14" black and white TV monitor. The experimenter was seated to the subject's right.

Subjects in the Imagery Instructions groups were asked to complete the Imagery Questionnaire. Subjects in the No-Instructions groups completed the questionnaire at the end of the session so as to avoid any implicit demand for imagery use that may results from completing the questionnaire.

Familiarizations trials. Subjects were first familiarized with the divergent thinking task. They were presented with the instructions described above and were then given two practice questions, one concrete and one abstract. They were given 90 secs. to respond to each question and were encouraged to give as many and as many different kinds of responses as possible.

Following these practice trials with the two questions, subjects were familiarized with the X-Checking task using the familiarization procedure described for Experiment 1, with the exception that practice was only given with High Interference (i.e., the Xs were displayed for 1.4 secs.). Subjects practised until they reached a criterion of two or fewer errors for two consecutive trials.

Subjects were then told that they would be given two more questions, and that they would have to respond to one concurrently with the X-checking task. Prior to presenting these two questions, subjects received a practice trial with both tasks concurrently. They were started on the X-Checking task and five seconds later were given one of the practice questions. Subjects in the Concrete experimental conditions were given the Concrete practice question. The abstract practice-question was given to subjects in the Abstract experimental conditions. This practice trial lasted for 90 secs.

Experimental trials. Immediately following these practice and familiarization trials, subjects were presented with the experimental questions. Subjects in the Imagery Instructions groups listened to the tape-recorded imagery instructions. They were reminded (approximately every minute) to use imagery during the experimental trials.

For the Interference trials, subjects were started on the X-Checking task. After five secs., the question was presented. Subjects responded to the questions orally, and were given four minutes to respond to each question.

The experimenter recorded the number of visual monitoring errors and the responses to the divergent thinking tasks.

Subjects were then asked to rate, on a scale of one to seven, the extent to which they used imagery to answer the experimental questions.

Scoring. Responses to the divergent thinking questions were scored for fluency and flexibility. Fluency scores were derived by counting the total number of responses that could be assigned to any of the categories. Flexibilty scores were the number of different kinds or categories of responses given to a question. For example, in response to the question of different uses for a cardboard box, numerous responses can refer to the same general use (eg., to draw on it, make a painting on it, use it for art, etc.,) and these differ from another category of responses (e.g, burn it to keep warm, use it to start a fire, use as combustible, etc.,). Thus, flexibility refers to the number of categories that were used by a respondent.

The procedures used for scoring the questions are presented in Appendix I, together with a description of the categories employed to derive the flexibility scores. Data comparing the inclusiveness of the categories in the four question can be seen in Appendix J. Descriptive data pertaining to the reliability of assignment of responses to categories are presented in Appendix K. Inspection of the information provided in these appendices indicates that the scoring criteria used by the experimenter were generally reliable in that independent judges were very likely to assign any given response to the same category.

In terms of inclusiveness, these categories were quite homogenous across tasks. For all four questions, relatively few categories accounted for most of the responses. Conversely, for all four questions, the least used categories accounted for very few responses.

Results.

Fluency scores. Fluency scores for each subject were derived by adding the total number of responses that could be assigned to any of the categories described as Appendix I. Mean Fluency scores for the eight experimental conditions are presented in Figure 6, and also appear in Table 8.

An Anova was performed on the Fluency scores using a three-factor mixed design, with Questions (Concrete/Abstract) and Instructions (yes/no) as between-subject factors, and Interference (No/High) as the within subject factor. The results of this analysis appear in Table 9. Neither the three-way interaction (Questions X Instructions X Interference) nor any of the two-way interactions reached statistical significance.

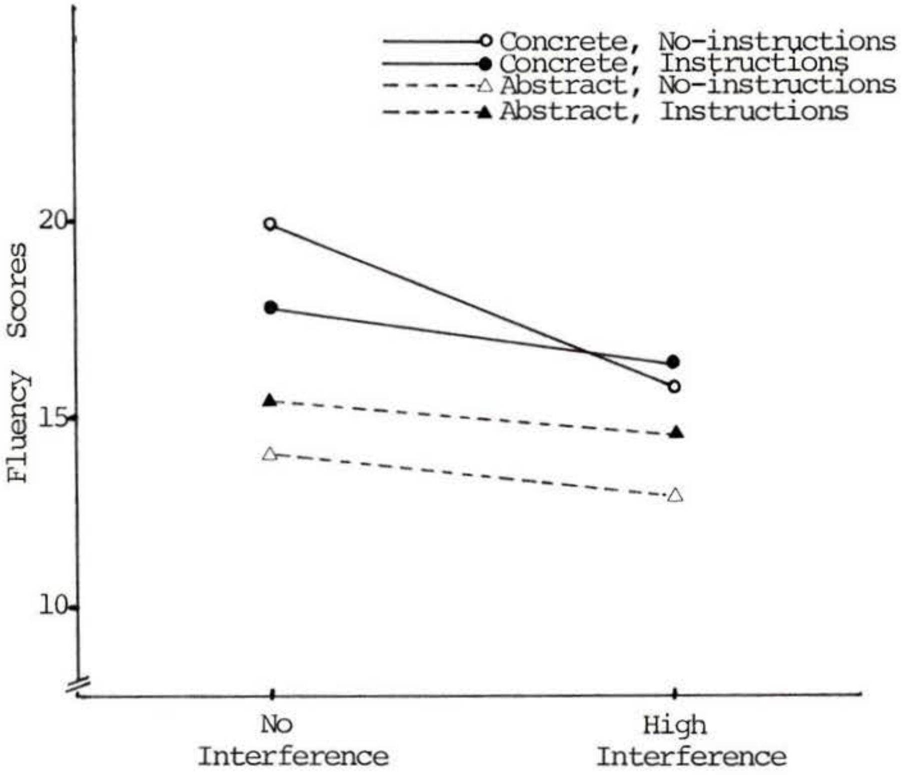

Figure 6. Mean Fluency Scores for Experimental Task Under No and High Interference.

Table 8: Means and Standard Deviations ( ) for Fluency, Flexibility, X-Checking Errors and Imagery Usage Ratings in the Four Experimental Conditions.

		Concrete Questions		Abstract Questions	
	Levels of Interf.	Imagery Instruc.	No Instruc.	Imagery Instruc.	No Instruc.
Fluency	No	17.7 (4.6)	19.8 (4.0)	15.3 (4.6)	13.8 (3.3)
	High	16.2 (6.9)	15.7 (6.3)	14.3 (5.0)	12.4 (4.3)
Flexibility	No	7.8 (1.8)	8.5 (2.0)	8.1 (2.2)	7.9 (2.3)
	High	7.4 (2.4)	7.1 (2.1)	7.8 (2.0)	7.4 (2.3)
X-Checking Errors	High	17.55 (10.2)	17.90 (13.5)	13.85 (9.3)	13.90 (11.1)
Rated Use of Imagery	No	5.7 (1.2)	5.9 (1.3)	5.4 (1.4)	4.8 (1.6)
	High	4.9 (1.7)	4.6 (1.6)	4.2 (1.3)	3.7 (1.3)

Table 9: Summary Analysis of Variance on Fluency Scores for Factors: Instructions, Questions and Interference.

Source	df	MS	F	p
Between Subjects				
Instructions	1	7.23	.19	
Questions	1	455.63	12.27	<.002
Instructions X Questions	1	63.50	1.68	
Error term	76	37.07		
Within Subjects				
Interference	1	160.00	12.70	<.002
Interference X Instructions	1	24.03	1.90	
Interference X Question	1	27.23	2.16	
Interf. X Intruc. X Quest.	1	12.10	.96	
Error term	76	12.60		

Note. Values of p>.05 not reported.

Two of the main effects were significant. Fluency scores were higher for Concrete than for Abstract questions (F[1,76]=12.79, p<.001). Higher Fluency scores were also attained in the No-Interference compared to the High Interference condition (F[1,76]=12.79, p<.001). Imagery Instructions did not have a significant effect on Fluency scores (F[1,76]=.19, p>.65).

Hypothesis 1 predicted that Fluency scores for the Concrete Questions would not differ between No and High Interference. Given that, overall, Fluency scores were higher under the No-interference condition and that there was no significant Question X Interference interaction, it follows that Hypothesis one was not supported.

Hypothesis 2 stated that for the Abstract Questions the No-Instructions group would attain higher scores than the instructed group. Since neither the main effect for Instruction nor the Instruction by Question interaction were significant, Hypothesis 2 was not supported.

Hypothesis 3 predicted that for Concrete questions under High Interference, the non-instructed group would achieve higher scores than their counterparts who received imagery instructions. This hypothesis was not supported by a planned comparison between the means for these two groups, which yielded a value of F(1,76)=0.06, p>.25.

For subjects in the Abstract, No Instructions group, the High Interference condition did not significantly affect their fluency scores (F[1,76]=1.55, p>.10). Thus, Hypothesis

4 was supported.

In summary, the main findings for Fluency scores were that higher scores were observed with the Concrete (vs. Abstract) questions and under No (vs. High) Interference. The expected interactions between Question and Instructions, and Question and Interference did not materialize.

Flexibility scores. Flexibilty scores were computed on the basis of the total number of different categories used by subjects in their responses to one of the questions. Mean Flexibility scores for each experimental condition are presented in Figure 7 and also are shown in Table 8.

An Anova was performed of the Flexibility scores using a mixed factorial design, with Instructions and Question as between-subject factors, and with Interference as the within-subject factor. Inspection of Table 10, which summarizes the results of this analysis, reveals that no interaction effects were significant.

The only significant finding was for the Interference effect, with $F(1,76)=4.42$, $p<.05$. Significantly higher Flexibility scores were observed under the No Interference than under the High Interference condition. Given this finding and the lack of Question by Interference interaction, the data supported the prediction, as stated in Hypothesis five, that for Concrete questions higher Flexibility scores would be attained in the No-Interference condition.

Hypothesis 6 predicted an interaction between

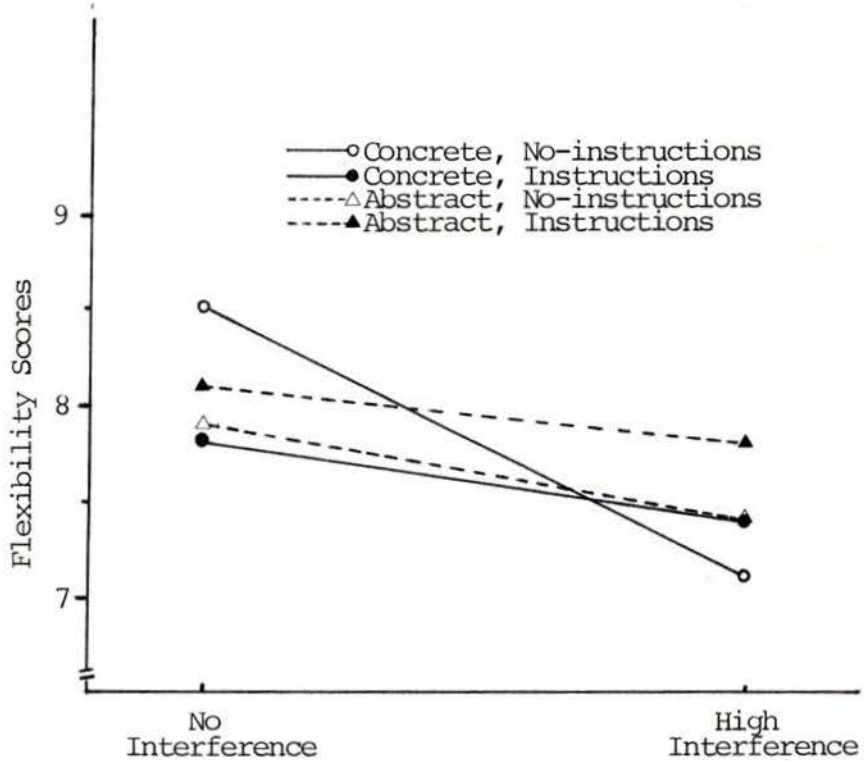

Figure 7. Mean Flexibility Scores for Experimental Task Under No and High Interference.

Table 10: Summary Analysis of Variance on Flexibility Scores for Factors: Instructions, Questions and Interference.

Source	df	MS	F	p
Between Subjects				
Instructions	1	.16	.03	
Questions	1	.51	.09	
Instructions X Questions	1	2.76	.49	
Error term	76	5.63		
Within Subjects				
Interference	1	16.26	4.43	<.05
Interference X Instructions	1	3.91	1.06	
Interference X Questions	1	1.81	.49	
Interf. X Intruc. X Quest.	1	1.41	.38	
Error term	76	3.67		

Note. Values of p>.05 not reported.

Interference and Instruction effects for the Concrete questions, whereby Imagery Instructions would enhance performance under No-interference and have the reverse effect under High Interference. Since none of the interactions were significant, this hypothesis was not supported.

Hypothesis seven stated that for Abstract questions the non-instructed group would receive higher fluency scores than the imagery instructed group. Given that neither the Instruction effect nor the Instruction by Question interaction were significant, Hypothesis seven was not supported.

In order to test Hypothesis eight, a planned comparison was made between the means of the No vs. High Interference for the Abstract/No-Instructions group. In support of this hypothesis, no significant difference was found between the No and High interference conditions for the Abstract/No-instructed group, with $F(1,76)=0.82$, $p>.05$.

In summary, the only significant effect obtained for flexibility scores was one for the Interference factor, with higher scores obtained for the No-interference condition.

X-Checking errors. One of the main features of this study was the use of the X-Checking task as a procedure to interfere with the use of imagery. In the High Interference condition, subjects responded to the questions while concurrently performing the X-Checking task (described in detail in Experiment 1). The number of X-Checking errors were presumed to reflect the degree of interference between the concurrent tasks. Therefore, more X-Checking errors were expected for those concurrent tasks that called for the sustainment of visual imagery.

Mean X-checking errors are presented in Table 8 and shown in Figure 8.

An Anova was performed on the X-Checking data using a Question by Instruction factorial design. A summary of this analysis is presented in Table 11. Inspection of this table reveals that neither the interaction nor the main effects (Instruction and Question) were significant. Although more errors were observed for the Concrete Questions, this difference failed to reach statistical significance. Therefore, hypothesis nine was not supported.

Rated use of imagery. Subjects in the four experimental conditions were asked to rate the degree to which they used imagery when answering the questions under No and High interference. The mean ratings appear in Table 8 and are also shown in Figure 9.

These data were submitted to an Anova using a mixed factorial design, with Instructions and Questions as repeated factors and with Interference as within factor. The summary of this analysis is presentend in Table 12.

As with previous criterion measures, none of the interaction effects proved significant. In terms of main effects, subject reported greater use of imagery with the Concrete than with Abstract questions, with $F(1,76) = 7.47$,

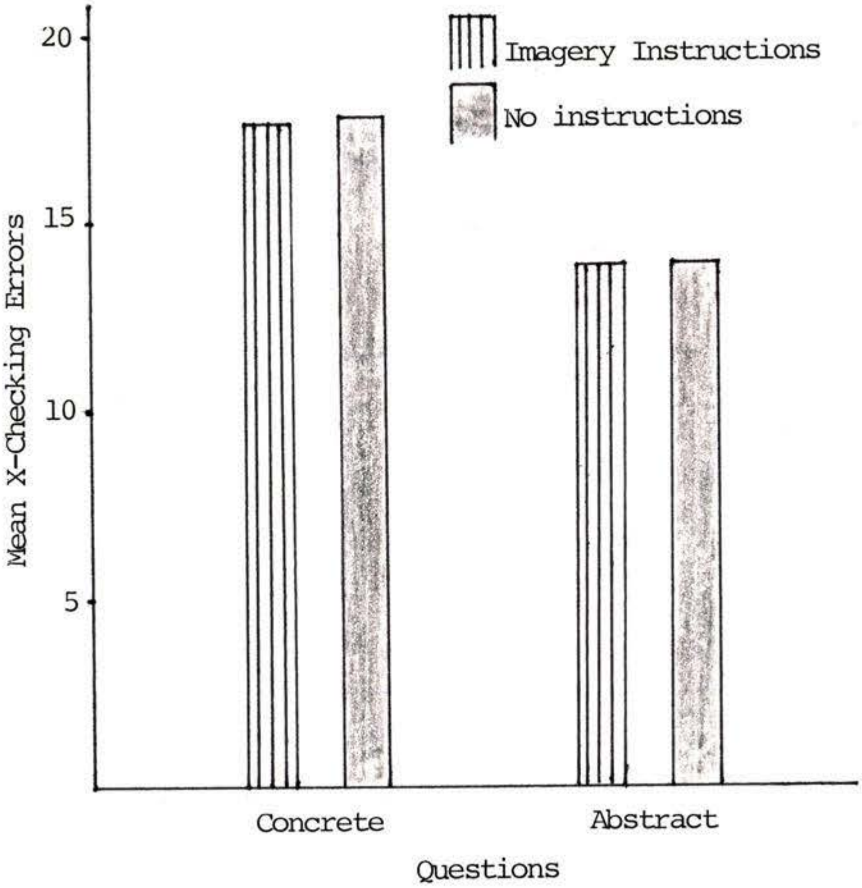

Figure 8. Mean X-Checking Errors Obtained for Concrete and Abstract Questions with and without Imagery Instructions.

Table 11: Summary Analysis of Variance on X-Checking Errors for Factors: Instructions and Questions.

Source	df	MS	F	p
Between Subjects				
Instructions	1	1.75	.01	
questions	1	306.91	2.47	
Instructions X Questions	1	.12	.00	
Error	76	124.12		

Note. Value of p>.05 not reported.

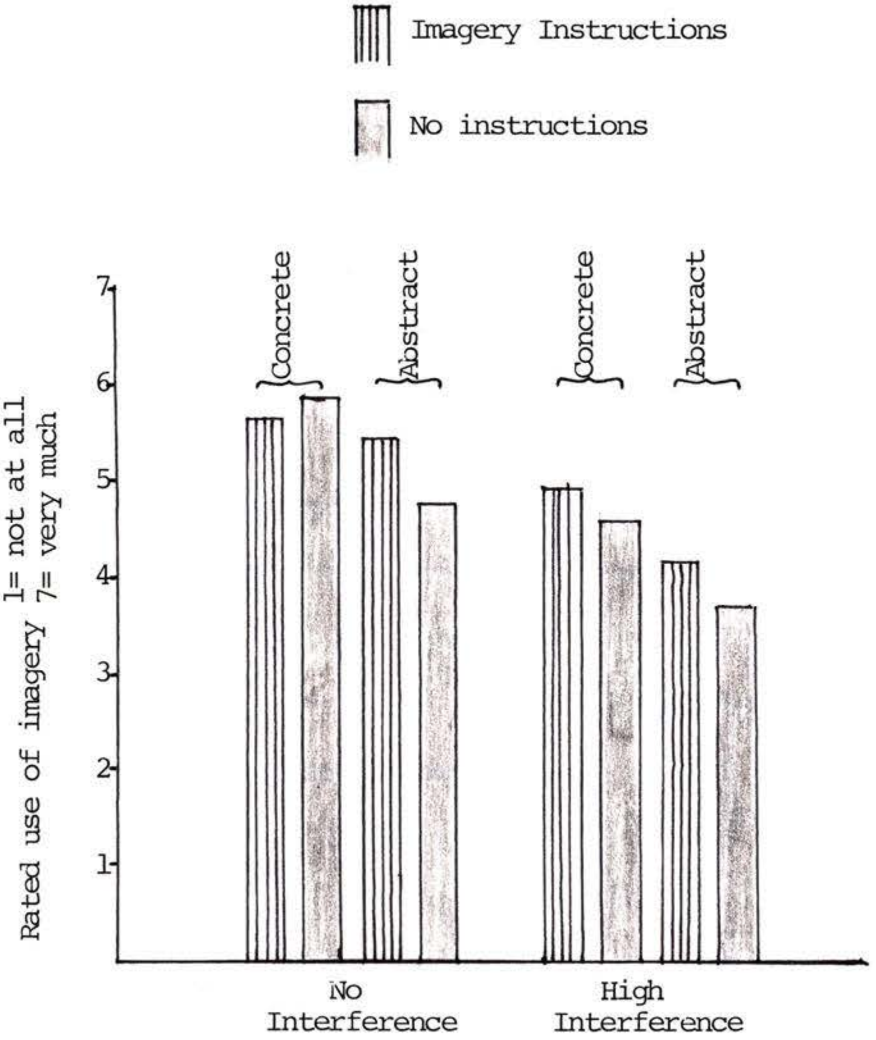

Figure 9. Use of Imagery Reported by Subjects in Four Experimental Groups Under No and High Interference.

Table 12: Summary Analysis of Variance on Imagery Use Ratings for Factors: Instructions, Questions and Interference.

Source	df	MS	F	p
Between Subjects				
Instructions	1	3.60	1.12	
Questions	1	24.03	7.46	<.01
Instructions X Questions	1	2.03	.63	
Error term	76	3.22		
Within Subjects				
Interference	1	48.40	52.36	<.001
Interference X Instructions	1	.90	.97	
Interference X Questions	1	.22	.24	
Interf. X Intruc. X Quest.	1	1.22	1.33	
Error term	76	.92		

Note. Values of p>.05 not reported.

$p<008$. Subjects also reported much greater use of imagery under the No-Interference condition relative to High-Interference, with a very significant $F(1,76) = 52.36$, $p<.001$. Interestingly, there was no significant difference between the Instruction groups as to their reported use of imagery. This suggests that Imagery Instructions did not predispose subjects to report greater use of imagery.

Imagery questionnaire scores. Subjects responses to each of the questions (see Appendix H) of the Imagery Questionnaire were given a score of three, two or one, depending on whether they judged the question to be, respectively, 'True', 'Not sure' or 'False' . Each question was a statement about the respondents' habitual use of imagery. The maximum possible score was 39.

The distribution of scores was negatively schewed. Scores ranged from 17 to 39, with a mean of 34.73 and a standard deviation of 4.54. The median score was 36. The majority of subjects attained a high imagery score, with 62% of repondents obtaining scores between 39 and 36. Given the nature of this distribution, the logical and statistical bases for separating low and high imagers became questionable. Therefore, a direct test of Hypothesis 10 by comparing high and low imagers was not undertaken.

Pearson product moment correlations were computed between the scores on the Imagery Questionnaire and other measures (e.g., total Fluency and Flexibility scores, X-checking errors). These correlations are presented in

Table 13.

Hypothesis eleven predicted a positive correlation between scores on the Imagery Questionnaire and Flexibility scores in the Concrete, No Instructions, No-inteference condition. As shown in Table 13, this obtained correlation was negative, weak and non-significant ($r=-.27$, $p>.12$).

Inspection of Table 13 reveals an interesting pattern. Significant and moderately strong correlations between Imagery Questionnaire scores and other criterion measures were obtained for only one of the experimental groups: subjects in the Abstract Question/ No Instructions group. Furthermore, this group's scores on the imagery questionnaire showed the highest correlation ($r=.59$, $p<.001$) with self-reported use of imagery during the experimental task.

Discussion.

The main findings of the second experiment can be summarized as follows: higher Fluency and Flexibilty scores were attained under No (vs. High) Interference, and higher fluency scores were obtained for Concrete (vs. Abstract) questions. Imagery instructions had no significant effect. These three variables (Questions, Interference and Instructions) did not interact.

These findings are not consistent with the predicted role of imagery in divergent thinking, namely that performance on concrete divergent thinking tasks would be

Table 13: Correlations between Imagery-Questionnaire scores and scores on other criterion measures in the four experimental conditions.

Criterion Measures	Imagery Questionnaire Scores for (group):				
	Concrete No instrc.	Concrete Instruct.	Abstract No instrc.	Abstract Instruct.	Total Sample
Fluency scores:					
No interf.	-.06	.09	-.22	-.21	-.07
High Interf.	-.10	.34	-.45*	-.04	.02
Flexibility scores:					
No inter.	-.27	.11	.66	-.02	-.01
High interf.	-.09	.29	-.39*	.17	.04
X-check. errors:	-.13	-.00	.53**	.12	.08
Rated use of imagery under:					
No interf.	.10	.46*	.59**	.39	.34**
High interf.	.14	.44*	.47**	.10	.25*

*p<.05
**p<.001

impaired when subjects' ability to sustain visual images was disrupted. In this analysis, the effects of imagery interference should be selective to those tasks that evoke the use of imagery (i.e., concrete tasks). In other words, a Question by Interference interaction was expected. It was not obtained.

The most parsimonious explanation for the present findings is task difficulty. We know from the teacher ratings (Appendix G) that the Abstract questions were rated as more difficult than the Concrete ones. On this basis, we can expect to obtain more responses for the easier items. We also know from the first study that tasks become more difficult when done concurrently with the X-checking task (see Figure 4). Thus, on the basis of increasing difficulty, we can expect fewer responses under High than No Interference.

Although task difficulty can explain these results, they were not a foregone conclusion. An opposite pattern of results was obtained in the first study, where the easiest task (Letter Tracking) was most disrupted by the interference procedure (see Figures 1 and 4, and Appendix E).

We cannot conclude that imagery plays no role in divergent thinking. Subjects reported using imagery in response to the questions, more so with Concrete than Abstract questions (see Figure 9). Furthermore, more X-Checking errors were made with Concrete than Abstract questions. Although this effect was not statistically significant, the direction of the trend is opposite to what would be predicted on the basis of task difficulty alone.

What appears to be the case is that the sustainment of visual images is not essential to performance on the divergent thinking questions. In contrast to the Letter Tracking task of the first study, concrete divergent thinking tasks of the type used in the second study can be performed by relying on other modes of representation, or other imagery processes. This would be consistent with Kosslyn's (1980) model of imagery, whereby different tasks call for different imagery processes (e.g., focus, enlarge, scan, etc.,). In fact, Kosslyn's model posits distinct processes for the generation and inspection of images. In the present study, subjects could not sustain images (under High Interference) but they did conjure images briefly, as witnessed by their reports. What functional role was played by these images is an open question.

The lack of effect for Imagery Instructions was not completely unexpected. Imagery instructions have not shown a consistent effect in previous studies and have not been tested with divergent thinking tasks. Different type of imagery instructions may prove effective. An interesting result in connection with instructions pertains to subjects' reported use of imagery. Neither Imagery Instructions nor responding to the Imagery Questionnaire predisposed subjects to report higher use of imagery. This suggests that reports of imagery use may be quite resistant to tacit task demands.

Kauffman's (1980) contention that imagery plays a greater role in the flexibility than fluency aspects of divergent thinking was not supported by the present study, but only in respect to sustained use of visual images. Other imagery processes may well contribute to divergent thinking. Furthermore, visual imagery may be critical to divergent thinking with figural information, as suggested by Guilford (1967).

CHAPTER IV

GENERAL DISCUSSION AND CONCLUSIONS

The main purpose of the first experiment was to determine whether the X-Checking task would interfere with the sustainment of visual images, reflected in the deterioration of performance in Letter Tracking. Results from all the criterion measures (i.e., task errors, X-Checking errors, tracking time, rated difficulty) consistently supported the conclusion that the X-Checking task had the expected interference effect on the Letter Tracking task. It disrupted performance on that task more than on others. The effect was interpreted in terms of interference with the sustainment of images, an interpretation supported by subjects' reports of greater use of imagery under No than High Interference. Thus, these findings provide strong support for the use of the X-Checking task as an imagery interference procedure, and are consistent with the claim (e.g., Finke, 1980) that imagery and visual perception share underlying processes.

The X-Checking task disrupted the sustaining but not the generation of images, as evident in its lack of effect on the Picture Words task. The critical factor responsible for this interference was the rate of stimuli presentation. The fastest rate, which displayed a stimulus (X or XX) for 1.4 seconds, allowed sufficient time to monitor the stimulus, make a response and also generate an image. This image could not be sustained for long because another stimulus appeared.

It is presumed longer presentation rates would allow the sustaining of images and would therefore be less disruptive to performance in the Letter Tracking task. Conversely, it is presumed that faster rates would begin to interfere with the generation of images, but would also make the X-Checking task increasingly difficult. One area of further investigations pertains to determining the rate of the X-Checking task which interferes with the generation of images but does not make it substantially more difficult. This would allow us to investigate the role of imagery generation vs. sustainment across a variety of tasks.

The X-Checking task has many features to recommend it as a procedure for manipulating imagery. It is flexible in that the rate of presentation and duration of trial can be varied. More importantly, the computer program keeps a record of X-Checking errors, which gives the experimenter an objective measure of interference as well as way of verifying that the interference task was in fact attended to. The development of this interference procedure is considered to be a contribution to the methodology available to imagery researchers.

The second study calls attention to a number of issues. The first one pertains to the use of self reports as evidence for the involvement of imagery in a given task. The first study showed very close correspondance between changes in performance as documented by objective data, such as task errors, and subjective reports such as difficulty ratings and spontaneous reports from subjects regarding the loss of the image during interference. Thus, there was a great degree of congruence in the first study between subjective reports and the objective data. In the second study, subjects also reported greater use of imagery under No than High Interference. However, given that the results of the second study failed to establish an imagery effect on divergent thinking, it is difficult to assert what functional role, if any, was played by these reported uses of imagery. It is clear that self-reports are not by themselves sufficient to establish imagery's role in a task. Collateral information must be obtained. Furthermore, as evident by the spontaneous reports during the Letter Tracking task and consistent with Ericsson and Simon's (1980) discussion of verbal reports as data, these reports are more valuable if they can be obtained as the task unfolds rather than after its completion.

Another issue pertains to using concreteness-abstractness as a criteria for determining whether imagery might be called for in a given task. There are two problems, one of the definition and the other of the locus of the attribute. When the stimulus is discrete or simple, such as stimulus words, it appears to be relatively simple to determine whether it is concrete or abstract. The situation becomes problematic for more complex stimuli. In the second study, a number of criteria were used to create abstract divergent thinking questions. It is conceivable that the thinking elicited by these questions was quite concrete. For instance, in response to the question, 'How do machines and technology affect people and society?', one can think of a specific machine, such as a car, having a specific effect, such as more frequent travel, just as in the case of the concrete questions one would think of a specific brick used for a particular situation. Furthermore, we may be mistaken in assuming that stimuli are concrete or abstract. Rather, these may be attributes that the person brings to a task, dependent on the context, task demands and cognitive capacities.

This brings our attention to a related issue. There are a small number of tasks, such as concrete vs. abstract stimuli in paired-associate learning or the mental rotation task, which have been shown to engage the imagery mode. Imagery researchers would benefit from a much larger inventory of tasks which are imagery mediated. It will be easier to understand how imagery works when we can be more certain when and where imagery is functional. The interference procedure used in this study could be one of the tools used to make this inventory.

Concerning the issue of imagery instructions, the second study found them to have no effect on performance on the divergent thinking tasks. Furthermore, subjects were more predisposed to use imagery by task demands, such as Concrete questions or No-interference, than by instructions. This was in spite of having provided subjects with fairly detailed instructions and with reminders during the task to use imagery. Perhaps greater training might have produced an effect. These results suggest we need to be cautious and refrain from assuming that the mere suggestion to use imagery will invoke its use or have beneficial effects. It is premature to suggest that imagery instructions will enhance divergent thinking. This question merits clarification through research that compares different instructional variables across different tasks within one study. We could then begin to specify those factors that make instructions effective for a given task.

As to the central question of this study, that of the contribution of imagery to divergent thinking and in particular Kaufmann's (1980) claim for a privileged role in the flexibility component, the present results do not support the proposition that the sustainment of images is essential to performance in these divergent thinking tasks. There was evidence to suggest that subjects were more predisposed to use imagery with the concrete questions, but imagery interference did not selectively disrupt performance for these concrete tasks. This may mean that these tasks can be performed using a verbal processes, or that the generation but not the sustainment of imagery plays a role in these tasks. What role might be played by image generation is an open question. It may be epiphenomenal, as Pylyshyn has suggested (1973) or it may be an essential one. Image generation might represent the essence of an idea that is then translated and elaborated through language. This issue also merits further investigation.

The present study does not rule out the use of sustained visual imagery in other kinds of divergent thinking tasks, such as with the figural stimuli used in parts of Torrance's (1966) test of creativity. Investigation of the role of visual imagery with figural divergent-thinking tasks would be a logical extension of the present study.

The present findings should generalize to the adult population, as suggested by pilot studies. Their generalization to special populations, such as the mentally retarded, and to younger age groups is an open question.

Finally, as previously noted, these results are compatible with a theory, such as Kosslyn's (1980), which posits distinct imagery processes rather than an undifferentiated imagery ability.

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APPENDIX A

Stimulus words for Picture Words task.

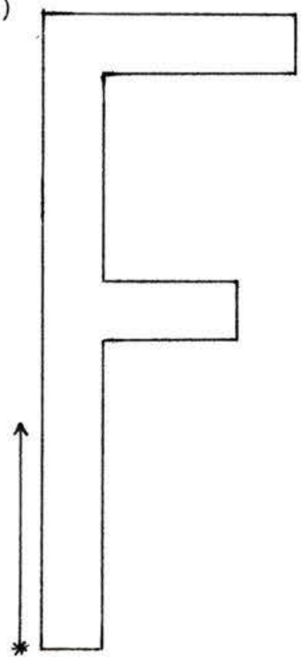
	(*)Imagery Value	(*)Frequency Value
Sample list:		
Pencil	6.37	40
Alligator	6.87	1
Quality	3.10	A
Sky	6.73	AA
Duty	3.17	AA
Library	6.73	A
Idea	2.20	AA
Hammer	6.73	34
Soul	2.13	AA
Experimental lists:		
List 1:		
Truck	6.60	23
Tower	6.53	A
Fate	2.37	A
Star	6.70	AA
Position	2.97	AA
Queen	6.57	AA
Attitude	2.77	A
Tree	6.77	AA
Method	2.63	AA
Moment	2.50	AA
List 2:		
Snake	6.90	28
Flag	6.60	A
Situation	2.53	A
Ship	6.67	AA
Knowledge	2.97	AA
Gold	6.47	AA
Excuse	2.77	A
House	6.67	AA
Amount	2.73	AA
Chance	2.50	AA
List 3:		
Fox	6.73	25
Coin	6.50	A
Fault	2.83	A
Cat	6.80	AA
Mind	3.03	AA
Book	6.43	AA
Event	2.90	A
Door	6.60	AA
Answer	2.77	AA
Truth	2.73	AA

(*) Imagery and frequency values from Paivio, Yuille & Madigan (1968).

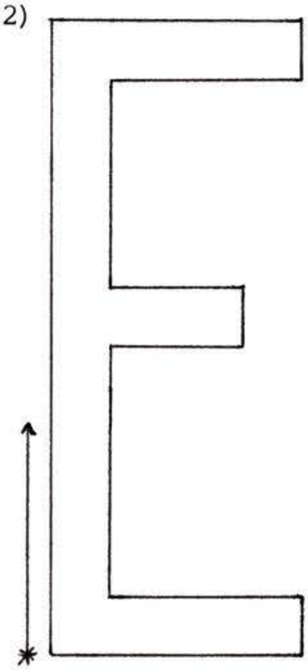
APPENDIX B

Stimulus letters for Letter Tracking task.

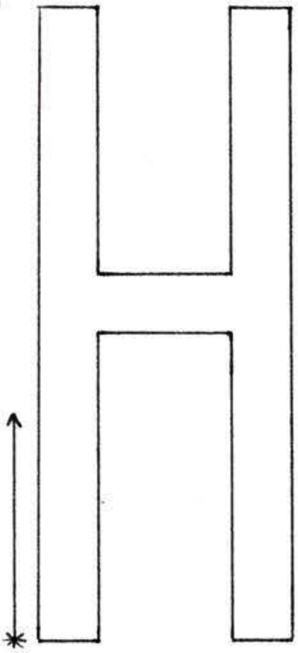
(1)



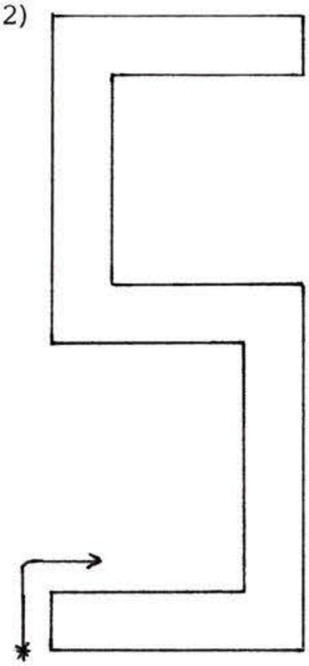
(2)



(2)



(2)



(1)= Practice item.
(2)= Experimental items.

Appendix C.

Stimulus words for Opposites task.

Sample list	Experimental lists		
	List 1	List 2	List 3
(1)Hard	(1)Deep	(1)Black	(1)Short
(1)Sweet	(1)Slow	(1)Cold	(1)High
(2)Acquit	(2)Abstract	(2)Gradual	(2)Spontaneous
(1)Sad	(1)Ugly	(1)Loud	(1)Old
(1)Sell	(1)Smooth	(1)Love	(1)Never
(2)Ferocious	(2)Private	(2)Bold	(2)Specific
(1)Sit	(1)Clean	(1)Push	(1)Dark
(2)Odd	(2)Success	(2)Temporary	(2)Rude
(2)Reject	(2)Simple	(2)Friend	(2)Liquid
(1)Fat	(1)Day	(1)Good	(1)Up

(1) These words were taken from Palermo and Jenkins (1964) and from Carrol, Kjeldergaard, and Carton (1962). They were selected because they have been found to elicit antonyms as their most frequent responses in word association tasks. They are also familiar words, and were included in the lists as the easy items.

(2)These words were selected on the basis of locally obtained data. Sixty eight high school students were given 24 words, presented orally at the rate of one every 7 secs. Students were asked to write an antonym for each word within the alloted time (7 secs.). Students' responses were scored as either correct or incorrect using The basic book of synonyms and antonyms (Urdang, 1978) as the criteria. Twelve words were selected because they were found to be difficult for high school students (i.e., a small percentage of students gave correct antonyms), and four words were selected because they were easy. The words presented to the students are shown below, with the percentage of students giving a correct antonym, and the eventual assignment in the study.

Stimulus word	Percent of students (N=68) who gave correct antonym	Assigned to:
Private	56.7%	List 1
Cruel	92.6%	Not used
Odd	79.4%	Sample list
Gradual	16 %	List 2
Abstract	16 %	List 1
Spontaneous	16 %	List 3
Wealth	63.1%	Not used
Temporary	75 %	List 2
Rude	76.5%	List 3
Acquit	21.9%	Sample list
Ferocious	61.7%	Sample list
Create	82.4%	Not used
Rapid	86.8%	Not used
Liquid	95.6%	List 3
Simple	97.1%	List 1
Horizontal	100%	Not used
Agile	43.9%	Not used
Greedy	70.6%	Not used
Specific	55.8%	List 3
Bold	55.8%	List 2
Jubilant	41.2%	Not used
Reject	79.4%	Sample list
Success	73.5%	List 1
Friend	97.1%	List 2

APPENDIX D

Computer program for X-Checking task.

```
100     home
110     input "r   ";k
120     input "nmbr   ";l
130     for i = 1 to 600: next i
140     for i = 1 to l
150     a = y
160     x = int (2 * rnd (1))
170     if x = 0 then x$ = "x"
180     if x = 1 then x$ = "xx"
190     if x$ = "x" then t = 206
200     if x$ = "xx" then t = 205
210     y = int (5 * rnd (1) + 1)
220     if y = a goto 210
230     home
240     on y goto 250,280,320,360
250     print tab( 20)x$
260     gosub 430
270     goto  390
280     print : print : print : print : print
        : print : print : print : print
        : print : print : print : print
290     print tab( 38)x$
300     gosub 430
310     goto 390
320     print : print : print : print : print
        : print : print : print : print :
        print : print : print : print : print
330     print tab( 20)x$
340     gosub 430
350     goto 390
360     print : print : print : print : print
        : print : print : print : print
        : print : print : print : print
370     print x$
380     gosub 430
390     home
400     next i
410     print q; "   ";p;"   ";f
420     goto 570
430     let c = 0
440     poke 49168,s: rem  clear keystrobe
450     for j = 1 to k
460     if c = 0 then 490
470     for g = 1 to 9:next
490     if peek (49152) < 128 then 540
```

```
500     let c = 1
510     s = peek (49152): if s = t then q = q + 1:
        goto 530
520     p = p + 1
530     poke 49168,s:rem clear keystrobe
540     next j
550     if c = 0 then f = f + 1
560     return
570     end
```

APPENDIX E

Data for familiarization trials in Experiment I.

Table 14. Means and Standard Deviations ( ) for Criterion Measures Obtained During the Familiarization Trials.

	Tasks					
	X-Checking		Picture Words	Letter Tracking	Opposites	Sound Tracking
	Low	High				
% Task Errors	2.0 (4.4)	2.0 (3.4)	19.7 (15.9)	3.4 (13.4)	23.8 (11.9)	8.7 (11.3)
Difficulty ratings			2.0 (.9)	2.7 (1.2)	2.3 (1.0)	4.3 (1.4)
Tracking time (secs.)				11.0 (3.7)		11.5 (3.6)

Note. The data for Low and High X-Checking task-errors are averaged over two practice trials.

APPENDIX F

Summary of multivariate tests for Experiment I.

Table 15

Multivariate F tests Using Wilk's Lambda Criterion.

	Source	df(Hyp.)	df(err)	F	p<
Task Errors	Task	3	33	30.19	.001
	Interference	2	34	10.97	.001
	Task X Interf.	6	30	4.77	.002
X-Checking Errors	Task	3	30	42.33	.001
	Task X Interf.	3	33	10.11	.001
Total Errors	Task	3	33	14.43	.001
	Task x Interf.	3	33	4.91	.006
Difficulty Ratings	Task	3	33	23.08	.001
	Interference	2	34	122.46	.001
	Task X Interf.	6	34	15.01	.001
Tracking Time	Interference	2	34	126.40	.001
	Task X Interf.	2	34	56.67	.001

APPENDIX G

Teacher ratings of Concrete and Abstract questions.

Twenty high-school teachers, each with more than seven years of teaching experience, responded to the questionnaire below. The purpose of the questionnaire was determine whether the Astract questions created for Experiment II were judged by professionals familiar with high-school students to require more abstract thinking than the Concrete questions.

Questionnaire.

Questions presented to high-school students differ along many dimensions. One of these is the concrete-abstract dimension. Some questions may require the student to think very concretely whereas other questions may demand more abstract thinking. Below you will find six questions. Please rate each question as to the degree to which it demands concrete/abstract thinking. Rate each question along a continuum, from '1' (very concrete) to '7' (very abstract). Feel free to use the whole range or you may think that all questions rate the same. Use your own judgment to rate the concrete/abstract demands of each question.

	Very Concrete						Very Abstract
1 How do technology and machines affect people and society. Give as many effects as you can think of.	1	2	3	4	5	6	7
2 Give me as many uses as you can think for a brick.	1	2	3	4	5	6	7
3 Give me as many uses as you can think of for a cardboard box.	1	2	3	4	5	6	7

4 How do weather and climate affect people and society. Give as many effects as you. can think of.	1	2	3	4	5	6	7
5 Give me as many reasons as you can think of why health is important to people and society	1	2	3	4	5	6	7
6 Give as many uses as you can think of for a metal coat hanger.	1	2	3	4	5	6	7

Results from this questionnaire showed the following: the mean abstractness ratings for the Concrete Questions (experimental items, numbers 2 and 3 above) were the same (=2.8) whereas the Abstract Questions (questions 1 and 4 above) received mean ratings of 5.25 and 5.15 respectively. A t-test showed that the Abstract questions were rated as significantly more abstract than the Concrete Questions, with $t(19)= 4.58$, $p<0.01$.

The same questionnaire, but with different instructions and anchor labels (1=very easy; 7= very difficult) was also completed by the same group of teachers. Results showed that the Abstract Questions were rated as significantly more difficult than the Concrete Questions, with $t(19)=4.41$, $p<.01$.

APPENDIX H

The Imagery Questionnaire used in Experiment II is shown below. The items were selected from Paivio's (1971) Individual Differences Questionnaire on the basis of a factor analytic study (Paivio and Harshman, 1983) which showed the items below loaded primarily on one factor presumed to be related to the habitual use of imagery.

Imagery Questionnaire

People report that they have mental pictures or images. They can remember an event by visualizing a mental picture of that event, or can use mental pictures to solve problems or plan actions. Whereas some people report frequent use of mental pictures, others report that they rarely use or are aware of mental images. The questions below are designed to determine the extent to which you experience mental pictures. Answer the questions below by putting a check (✓) in the appropriate column to indicate 'True', 'Not Sure' or 'False' for each question.

	TRUE	NOT SURE	FALSE
I can easily picture moving objects in my mind	___	___	___
I have only vague visual impressions of scenes I have experienced	___	___	___
I think most people think in terms of mental pictures whether they are completely aware of it or not	___	___	___
I can close my eyes and easily picture a scene I have experienced	___	___	___
When someone describes something that happened to him, I sometimes find myself vividly imagining the events that happened.	___	___	___
I never use mental pictures or images when trying to solve problems.	___	___	___
I find it difficult to form a mental picture of anything	___	___	___
Listening to someone recount his experiences does not usually arouse mental pictures of the incidents being described	___	___	___
My thinking often consists of mental pictures or images	___	___	___
I do not form a mental picture of people or places when reading of them	___	___	___
I often enjoy the use of mental pictures to reminisce	___	___	___
When remembering a scene, I use verbal descriptions rather than mental pictures	___	___	___
I often use mental images or pictures to help me remember things.	___	___	___

APPENDIX I

Criteria for deriving Fluency and Flexibity scores.

Responses to all four questions were assigned to categories. These categories were derived by first surveying all responses to determine commonalities in the types of responses given to questions. For example, the question on the uses for a brick elicited some common classes of uses, such as using it for some construction purpose, as a tool or as a weapon. An initial set of categories for each question was established. Using these categories, responses were scored to determine whether these categories were unambiguous and capable of classifying most responses. The system of categories was further refined so that approximately 95% of the responses could be assigned to one of the categories. Most of the other responses were assigned to a miscellaneous category. These were valid responses but too infrequent to create a category to cover them. Some responses (less than .5%) were not scored for being too vague, totally irrelevant or a repetition of a previous response.

The Fluency score was the total number of responses that could be assigned to any of the categories. The Flexibility score was the total number of categories used by a subject in his responses to a question.

The categories for each of the four questions are described below, with sample responses. They are listed in order of their frequency, with the most frequently used category listed first.

Categories for Concrete Question 1: Uses for a brick.

Category 1. Use for construction - conventional. Sample responses: build a house, make a wall, build a chimney, build a fire place.

Category 2. Use for construction - unconventional. Sample responses: build a dog house, build a boat, make stoves, build a book case, make a road, build a table.

Category 3. Use as a weight or to hold things down. Sample responses: use as a paper weight, keep plastic down for a tent, stop things from blowing, keep front of boat down, use as an anchor.

Category 4. Use as a tool to pound or scrape. Sample responses: to open a coconut, to flatten a box, squash apples, flatten out metal, hammer a nail, scrape something, grind grain.

Category 5. Use to prop up, support or raise off the ground. Sample responses: stabilize short leg of a chair, to place thing on it, hold boat up, prop up a car, hold up a sofa, as a booster to make something taller.

Category 6. Use brick as a weapon. Sample responses: to beat someone, for self-defense, hitting people on the head, throw at people you hate, tie on rope and hit people on the head.

Category 7. Use as an art material, or for painting or writing. Sample responses: make a carving, make a design with it, paint or draw on it, use for art, make a sculpture, write a message on it, use instead of canvass.

Category 8. Use brick as a stopper. Sample responses: stop car from from rolling, block a door, put under car wheels, door stop, use as a stopper, to block something.

Category 9. Use as part of a game or as toy. Sample responses: as toys, stack and use as blocks, throw for shotput, pet rock, use for game, play catch, as hockey puck, dance around it, use as building blocks.

Category 10. Use material from crushed brick. Sample responses: make it into dirt and dust, make pigment, make clay out of it, crush and use as sand, grind it up and use for paths, grind it up and use for cosmetics.

Category 11. Use for decoration. Sample responses: to decorate with, to make a pattern, make an ornament, hang it from tree as ornament.

Category 12. Use as insulation, to protect from heat. Sample responses: put behind a stove, put hot things on it, line inside a wood furnace, put hot pots on counter, hold ashes in fire.

Miscellaneous. Uses for bricks that do not be assigned to any of the above categories. Sample responses: heat it up and use as iron, to test bonding strength, file it and make it round for a wheel, heat it up and cook an egg on it, derail a train, hide a key, make noises with it.

Categories for Concrete Question 2: uses for a cardboard box.

Category 1. Use cardboard box for storing things. Sample responses: to store things, put milk in it, keep keepsakes, for storage, to store shoes.

Category 2. Use cardboard box for keeping or trapping animals. Sample responses: keep kittens, make a cat box, put animals in it, cages for pets, make a nest for a bird.

Category 3. Use cardboard box for play material. Sample responses: make a doll house, make a sword, use for puppet theatre, play game by throwing it around, play house.

Category 4. Use cardboard box as container for moving or for carrying things. Sample responses: carry groceries, carry stuff, collect eggs, use for moving.

Category 5. Use cardboard box for furniture. Sample responses: use as table, for baby cradle, as chair, for book racks.

Category 6. Use cardboard box for art and crafts material. Sample responses: make mobile, cut up and draw on it, paint on it, cut shapes, for drawing on.

Category 7. Use cardboard box to package or mail things. Sample responses: to send things in the mail, package gifts, for packaging, ship things in it.

Category 8.Use cardboard box to make or repair things. Sample responses: make a lamp shade, repair a shoe, make a hat, fix broken glass, make book covers.

Category 9. Use cardboard box as combustible. Sample responses: burn it for fire, to burn, start a fire.

Category 10. Use cardboard box to protect or cover something. Sample responses: to keep water or dirt from something, to protect something, cover things up, cover a windshield, cover a whole.

Category 11. Use cardboard box for writing material. Sample responses: write on it, make signs, use for advertising.

Category 12. Use cardboard box to hide things. Sample responses: to hide something, for kids to hide stuff in, hide stuff in it.

Category 13. Use cardboard box for building material. build a wall, to build things, make a divider, make a tower.

Category 14. Use cardboard box for garbage container. Sample responses: put garbage in it, keep rubbish in it, put compost in it, as waste paper basket.

Category 15. Use cardboard box as pot for plants. Sample responses: put plants in it, grow tomatoes in it, plant things in it.

Category 16. Use cardboard box for clothing or costumes. Sample responses: make halloween costumes, wear it as shorts.

Category 17. Use cardboard box as a mat. Sample responses: put it on the floor as mat, use as entrance mat.

Miscellaneous. These responses could not be assigned to any of the above categories. Sample responses: live in it, watch it decompose, stand on it, use as straight edge.

Categories for Abstract Question 1: How do weather and climate affect people and society.

Category 1. Affects kind and/or level of non-work activity. Sample responses: cold climates have more winter sports, sporting activities available, want to do more when sunny, what you do on weekends.

Category 2. Affects moods and temperament. Sample responses: feel happy when sunny, affects our mood, get grumpy when weather is bad, affects people emotionally.

Category 3. Affects business productivity and economic development. Sample responses: countries with different climates produce different things, creates employment in different areas like waterproofing, when it is too cold you can't work, need for different products like umbrellas.

Category 4. Causes disaster. Sample responses: tidal waves cause epidemics, can destroy a city, can bring destruction, tornadoes kill people.

Category 5. Affects where people live and settle. Sample responses: people tend to live in warmer places, makes you want to move to a place, affects where people live, can't live in the extremes.

Category 6. Affects type and amount of food available. Sample responses: if there is no rain food will not grow, affects food and crops, food available to eat, crops are dependent on weather.

Category 7. Affects transportation. Sample responses: need a snowmobile if there is a lot of snow, type of car you drive, affects transportation, hinder space crafts.

Category 8. Affects type of clothing. Sample responses: affects attire, clothes you wear, clothes you buy, different clothing needed for different climates, affects style.

Category 9. Affects fauna, flora or soil. Sample responses: affects furs on animals, affects plants, soil, trees, vegetation, rain waters plants.

Category 10. Affects health and sanitation. Sample responses: weather can be bad for people's health, too much sun gives you sun stroke, can get frostbitten, people tend to get sick when it is cold.

Category 11. Affects type of shelter needed. Sample responses: climate affects buildings and structures, buildings are adapted to climate, affects type of shelter, style of houses.

Category 12. Affects lifestyle. Sample responses: lifestyles are changed by weather, affects the way people live, affects our lifestyles, have to learn to adjust to weather.

Category 13. Affects level of productivity. Sample responses: work less when weather is good, when weather is bad there is less absenteeism, might be hard to go to work, might want to skip work.

Category 14. Affects vacation plans and destinations. Sample responses: affect travel plans, decide where to holiday because of weather, go skiing where there is snow.

Category 15. Affects interpersonal relationships. Sample responses: affects relations with others, serves as a conversation piece, keeps people together, good thing to talk to other people.

Category 16. Affects people's physical characteristics. Sample responses: affects shin color, people's weight, how people look, makes people's skin different color.

Category 17. Affects weather-sensitive occupations. Sample responses: makes trouble for farmers, affects sailors, important for farmers.

Category 18. Affects amount of heating required. Sample responses: how much heating you need, how much hydro is used, in some parts you need air conditioning.

Miscellaneous. Responses that could not be clearly assigned to any of the above categories. Sample responses: gives police clues to a murder, rain keeps things clean, make life more interesting, produces fresh water.

Categories for Abstract Question 2: What are the effects of machines and technology on people and society?

Category 1. Make life easier and provide conveniences. Sample responses: life is easier with more conveniences, lifestyle not as much work, improved standard of living.

Category 2. Affect the speed, diversity and/or efficiency of production. Sample responses: cars are made faster, do things fast and efficient, people can do more things in a day, machines speed up production.

Category 3. Affect the level of emplyment. Sample responses: there's loss of jobs, creates employment, computers create new jobs, robots replacing people.

Category 4. Affect travel and transportation. Sample responses: transportation is now more convenient, technology helps transportation, travel is easier and faster.

Category 5. Affect health and medicine. Sample responses: people kepst alive longer, allow medical breakthroughs, assist health and medicine, new cures for deseases.

Category 6. Make possible scientific achievement and discoveries. Sample responses: scientific advances are quicker, allow for exploration in space and the oceans, makes reasearch easier, can discover new things.

Category 7. Produces stress and alienation in interpersonal relations. Sample responses: people are less open, there is animosity between people, fear of nuclear bombs, makes people feel smaller.

Category 8. Threat man and environment. Sample responses: increased threat of total destruction, technology of warfare endangers people, create pollution.

Category 9. Amount of knowledge has increased and people are more informed. Sample responses: people are more aware, average person is brighter, learning more about our own earth, expanded horizon.

Category 10. Facilitates communication. Sample responses: easier to find things out, talk to people around the world, get information quicker.

Category 11. Affect how people learn and the need for education. Sample responses: more education is now needed, computer used for teaching, more training to operate machines.

Category 12. Affect recreation and entertainment. Sample responses: new forms of entertainment, sci-fi effects in movies are more varied, machines help us in our leisure time.

Category 13. Increased leisure time. Sample responses: more free time, increased leisure time, less working hours per week.

Category 14. Increased rate of change.Sample responses: life has speeded up, life has faster pace, people have to adapt to rapid changes, makes everything faster.

Category 15. Machines and technology are controlling society. Sample responses: machines are taking over, they'll be running our country, computers run things by themselves, people can be programmed.

Category 16. Raised level of expectations. Sample responses: people expect more, want more, want to get things.

Category 17. Affect the accumulation and distribution of wealth. Sample responses: more money for one person, sell more and make more money, other people made poorer.

Category 18. Create dependency on machines. Sample responses: we've become dependent on TV, don't do things for ourselves, dependent on technology.

Category 19. Allow us to do things we hitherto could not. Sample responses: computers working on problems we could not, can do work humans can't, allow us to do different things like fly.

Category 20. Affect how people think of the world and themselves. Sample responses: becoming aware of what man can really do, allow people not to rule things out, affect the way we think of ourselves.

Category 21. Make people think less. Sample responses: people don't have to think anymore, don't have to use our brains, getting dumber.

Category 22. Everything is more artificial, less natural. Sample responses: everything is synthesized, makes food taste different, things are less natural.

Miscellaneous. Responses were assigned to this category if they could not be assigned to any of the above. Sample responses: prompts political debate, made people lazy, feel more confident, causes cities to get bigger, affects size of the family.

APPENDIX J

Inclusiveness of categories used for obtaining flexibility scores.

The categories used to derive Flexibility scores are described in Appendix I. Table 16 below shows the percentage of responses assigned to the categories for each question.

Table 16

Percentage of responses assigned to each response category.

Concrete Questions				Abstract Questions			
Question 1		Question 2		Question 1		Question 2	
Cat.#	% of Resp.	Cat.#	% of Resp.	Cat.#	% of Resp.	Cat.#	% of Resp.
1	32.2%	1	28.0%	1	16.5%	1	14.9%
2	11.8%	2	10.6%	2	14.8%	2	11.2%
3	11.7%	3	8.4%	3	9.7%	3	9.1%
4	9.9%	4	8.1%	4	9.4%	4	9.1%
5	6.6%	5	6.7%	5	6.6%	5	6.4%
6	4.7%	6	5.9%	6	5.6%	6	6.4%
7	4.6%	7	4.4%	7	5.1%	7	5.2%
8	3.8%	8	4.3%	8	4.5%	8	4.5%
9	3.5%	9	3.4%	9	3.9%	9	4.5%
10	2.5%	10	3.2%	10	3.7%	10	4.3%
11	1.6%	11	3.2%	11	3.0%	11	3.4%
12	1.4%	12	2.9%	12	3.0%	12	3.4%
Misc.	5.7%	13	1.8%	13	2.2%	13	1.9%
		14	1.5%	14	1.9%	14	1.7%
		15	1.2%	15	1.7%	15	1.7%
		16	1.0%	16	1.3%	16	1.4%
		17	.8%	17	1.1%	17	1.2%
		Misc.	4.8%	18	.9%	18	1.0%
				Misc.	5.3%	19	1.0%
						20	1.0%
						21	.9%
						22	.7
						Misc.	5.7%

Note. The total number of responses obtained for each question were as follows: Concrete Question 1= 634, Concrete Question 2= 729; Abstract Question 1= 534, and Abstract Question 2= 581.

APPENDIX K

Reliability of experimenter's assignment of responses to categories.

In order to determine whether the experimenter's assignment of responses to categories was reliable, three judges were asked to categorize 240 responses (60 responses to each of the four questions). The categories used for each question are described in Appendix I.

The rationale for the categories was explained to the judges and sample responses were shown. Sixty responses for each of the four questions were randomly selected. The judges were given these responses and had to assign them to one of the categories. Table 17 below summarizes the degree of agreement between the experimenter and the judges' assignment of responses to categories.

Table 17

Frequency of agreement between experimenter and judges' assignment of questions to categories.

	Number and percentage ( ) of responses assigned to the same category by experimenter and:			
	All 3 judges	2 of 3 judges	1 of 3 judges	None
Concrete:				
Question 1	38(63.4%)	15(25.0%)	2(3.3%)	5(8.3%)
Question 2	48(79.9%)	4(6.7%)	4(6.7%)	4(6.7%)
Abstract:				
Question 1	42(70.0%)	12(20.0%)	3(5.0%)	3(5.0%)
Question 2	39(65.0%)	8(13.3%)	11(18.4%)	2(3.3%)

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Effect of Imagery Interference, Task Concreteness and
Imagery Instructions

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