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Creativity, Attention Deployment, and Equilibration

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CREATIVITY, ATTENTION DEPLOYMENT,
AND EQUILIBRATION

BY

JOSEPH R. McALLISTER, Jr.

A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE
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Abstract

This investigation examines the relevance of Piagetian theory for understanding creativity. Selected studies of creativity using a variety of methodologies and deriving from diverse theoretical orientations are reviewed with the purpose of demonstrating a common link among seemingly unrelated investigations, namely, their congruence with a Piagetian theory of creativity.

Three subtopic areas are considered in more detail: attention deployment of creatives, similarities and differences between creatives and schizophrenics, and Kuhn's theory of scientific revolutions. An attempt is made to relate the findings from each of these areas to a Piagetian perspective on creativity.

Subjects were 104 undergraduate students. A tachistoscopic-type word recognition task was developed in an attempt to operationalize the Piagetian constructs of assimilation and accommodation. Recognizing words from a designated scheme served as an operational measure of assimilation. Recognizing words related to the scheme, and unrelated words, served as measures of moderate and extensive accommodation, respectively.

Words were presented under three instructional sets: Equal, Primary, and Exclusive attention conditions. Instructions related to the proportion of attention subjects

were directed to give Scheme vs. Unrelated words. Subjects also completed 30 trials of the Muller-Lyer illusion. The decrement in the effects of the illusion over trials was used as an additional measure of accommodation. Creativity was assessed using the Wallach-Kogan tasks.

Creativity scores were associated with the number of Unrelated words recognized under both the Primary and Exclusive instructional conditions. No relationship was found between creativity and the recognition of any of the word-types under the Equal attention condition. Under the Exclusive condition, high-creatives also recognized more Scheme words than did low creatives. Related words acted as a suppressor variable under Exclusive and Primary conditions, increasing the predictive power of the Unrelated words. The suppressor effects suggest creatives may be characterized by high levels of attention toward significant discrepancies with expectations and comparatively low levels of attention to moderate discrepancies. Performance on the Muller-Lyer was unrelated to either creativity or the attention deployment measures.

Results are seen as offering support for a relationship between creativity and incidental learning, and for the Piagetian view that creativity is related to an ability to accommodate to stimuli discrepant with one's expectations. Results are inconsistent with the hypothesis that high-creatives are characterized by greater attentional

capacity than low-creatives.

Implications of the relationship between creativity and accommodation to anomaly are discussed in relation to the course of scientific progress. Modifications of the experimental design which might further explicate the process by which high-creatives accommodate to discrepant events are discussed.

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Introduction

Statement of the Problem

After more than 30 years of fairly intensive study in creativity, no adequate theoretical framework for understanding or researching creativity has been able to withstand empirical scrutiny. Therefore, the literature on creativity appears splayed or even contradictory. Nevertheless, certain trends and commonalities can be discerned. A select portion of the literature is reviewed in this section and the Piagetian theory of equilibration is offered as a possible unifying framework for considering seemingly unrelated studies in creativity.

In addition to this general review, three subtopic areas are considered in greater detail. Kuhn's theory on scientific revolutions, similarities and differences between creatives and schizophrenics, and the attention deployment styles of creative individuals are each considered in turn.

Kuhn's theory of scientific revolutions is introduced for the purpose of illustrating the essential similarity between his theory and Piaget's theory of equilibration. When juxtaposed it is evident that the two can be considered complementary theories of creativity, albeit with diverging points of focus. The intention in comparing the

characteristics of schizophrenic, creative, and "normal" groups is to provide a framework for considering the hypothesis that differences in equilibrative processes may be used to account for behavioral similarities and differences among these groups. Likewise, an alternative interpretation of the literature on the attentional styles of creative individuals is proposed--that the unusual attention deployment style of creative individuals is a behavioral manifestation of their propensity for accommodating to perturbations.

Review of the Literature

The presidential address of J. P. Guilford (1950) before the American Psychological Association in 1950 incited a flurry of research in creativity that continued for about a quarter of a century. Over the last decade or so, however, research in creativity has again waned. The difficulties in defining and measuring creativity have apparently squelched much of the enthusiasm for this area of study.

Although numerous theories of creativity have been put forward, few have proven to be fecund. In fact, the bulk of the research in creativity would appear to be ungrounded in any theoretical position. For the most part, existing research on creativity would seem to be independent of the

various theories of creativity. Consequently, the impression gleaned from a survey of creativity research since 1950 is of a somewhat disjointed collection of bivariate studies lacking unity and coherence. And over the last few years, this succession of bivariate studies has begun to dwindle as well. As Stein and Heinze (1960) observed more than twenty years ago,

Everything that might be regarded in one way or another as important in a study of any individual--his heredity, his childhood, his adolescence, his adult personality, his intelligence, his perceptual process, his problem-solving behavior, etc.--has been considered in some study of the creative individual. (p. 2)

In spite of the wide range of characteristics and abilities which have been associated with creativity, neither an acceptable profile of the creative individual nor an adequate delineation of the creative process has yet to emerge.

An attempt will be made in this paper to review a select group of creativity studies and then to suggest a possible common thread which may serve to tie together a subset of the research and thinking in creativity.

Many investigators and theorists who have approached creativity from a wide variety of conceptual backgrounds have reached the conclusion that people employ a cognitive/perceptual style that differs from that of less creative individuals. More specifically, creative individuals seem to exhibit a receptivity or an attraction for environmental events which other people would tend to

find disconcerting. Torrance (1962) has asserted that "the essence of creativity lies in a sensitivity to defects, the recognition of a disturbing element" (p. 42). Similarly, Guilford (1950) portrays creatives as exhibiting a "sensitivity to problems," and Barron (1970) has suggested that a fundamental property of creativity is the ability to find or construct order out of apparent chaos.

Barron's conclusions have been derived in part from his research on the aesthetic preferences of creative individuals, indicating that creatives tend to prefer the complex and asymmetrical to a greater extent than noncreatives (Barron, 1958, 1971; Holland, 1961). By way of explanation, Barron (1958) proposed that when viewing the more complex stimuli, creative individuals are able to synthesize "an elegant new order more satisfying than any that could be evoked by a simpler configuration" (p. 153). Summarizing several studies comparing Rorschach responses of high and low creative groups, Barron (1958) concludes that original individuals are much more likely to integrate the blot details into "one comprehensive, synthesizing image" (p. 153) than are less creative subjects. According to Barron, this tendency reflects the creative individual's "very strong need to achieve the most difficult and far-reaching ordering" (p. 153). In addition, using the methodology developed by Asch (e. g., 1956), Barron (1955) found creative subjects conformed to group consensus less

often than did noncreatives. According to Barron, the creative subjects were more able to deal with the contradiction inherent in their nonconformity, whereas the noncreatives felt obliged to maintain order through "a process of exclusion of the evidence, and in this instance, at the cost of correct judgement" (p. 163).

Barron's findings are also consistent with the position advocated by Taylor (1976) who has suggested that when a disparity between inner and outer worlds exists, the resulting tension can be reduced via one of two means: "either the person alters his personal perceptions to correspond with the social environment, or the person alters or reorganizes the environment congruent with his personal world resulting in a new environmental organization" (p. 304). According to Taylor, creative subjects are more inclined to reorganize the environment whereas less creative people are more willing to be altered by the environment.

Schaefer (1973) and MacKinnon (1968) have both referred to an "openness to experience"--both external and internal experience--as being characteristic of the creative person. According to MacKinnon, the creative individual is able to tolerate "conflicting values and dispositions within himself and effect some kind of integration" (p. 12). Through research utilizing adjective checklists, Schaefer has reached the same conclusion. The more creative subjects in Schaefer's studies selected a greater number of adjectives

as self descriptive than did less creative subjects. Furthermore, creative females selected more unfavorable as well as favorable adjectives as self descriptive than did the noncreative subjects.

While taking a more cognitive perspective on the question of creativity, Bruner (1973) concurs with the theme of greater veridicality evident in the perception of creative individuals. Bruner has reported that the creative individual possesses a less stereotypic system for encoding information and broader cognitive categories for the incorporation of new material into previously learned material than do noncreatives.

In a more psychoanalytic vein, Heist (1968) has attempted to relate creativity to the "capacity to tolerate and express effectively the richness of inner life, the anxiety and the psychic turbulence" (p. 111). Echoing sentiments expressed above, Heist suggests that the creatives are "challenged by disorder and incompleteness."

Finally, Stein's (1962) comments on the affinity of creatives for the incongruous or the unsettling serve as a summary of the preceding discussion and provide a surprisingly direct connection to the section that follows:

One might say that homeostasis has been disturbed, that there is a lack of closure or that there is a lack of satisfaction with the existing state of affairs. The creative individual may actively seek to disturb the equilibrium he previously attained or he may be responsive to disequilibria already existing in the environment. (p. 86-87)

Piagetian Theory and Creativity

Stein's observations are remarkably consistent with Piaget's writings on cognitive equilibration. The juxtaposition of a passage from Piaget (1977a) illustrates the commonalities in thinking, and even in the terminologies employed:

Attained equilibrium is limited and restrained, and there is a tendency to go beyond it to a better equilibrium.... In other words, equilibration is the search for a better and better equilibrium in the sense of an extended field, in the sense of an increase in the number of possible compositions, and in the sense of growth in coherence. (p. 12)

The recognition and exploitation of incongruity or "nonbalance" plays a central role in Piaget's concept of equilibration:

One of the sources of progress in the development of knowledge is to be found in nonbalance as such which alone can force a subject to go beyond his present state and seek new equilibriums. (Piaget, 1977b, p. 12)

Thus it may be adaptive for disturbing elements to be not only tolerated but actively sought.

For Piaget, environmental events must be compatible with existing cognitive structures of the organism (the organism's "schemes") in order for the events to be assimilated into those structures. "Assimilation essentially means interpreting or construing external

objects and events in terms of one's own presently available and favored ways of thinking about things" (Flavell, 1977, p. 7). When, on the other hand, environmental events are not entirely compatible with existing schemes, the results are nonbalance and disequilibrium. The organism then attempts to restore equilibrium, or to achieve a new, more complete equilibration, through the process of accommodation, that is, the process of modifying the scheme in order to make it more compatible with the presenting environmental events and subsequently make assimilation possible. Without accommodation there could be no change or development (Geber, 1977). Change, novelty, and incongruity are the source of "nonbalance," a state which the organism is motivated to resolve.

In general, Piaget (1977b) recognizes two ways in which nonbalance can be managed by the organism, which he refers to as methods of compensation. The two types of compensations are inversion and reciprocity. Inversion consists of the cancellation or denial of the disturbance. Shortly before his death, Piaget had begun to refer to this process as a kind of "cognitive repression" which succeeds in neutralizing the disturbance (Inhelder, 1982). Reciprocity, on the other hand, consists of "modifications of the scheme to accommodate it to the initially disturbing element" (Piaget, 1977b, p. 26). Perhaps creative individuals, being drawn toward disturbances, tend to

utilize inversion relatively less often and reciprocity relatively more often than is characteristic of less creative individuals. This implies that creative individuals are less likely to overlook or dismiss information which conflicts with their beliefs or expectations. They are more likely to make use of discordant data to achieve a synthesis of it and existing cognitive structures while, concurrently, producing a modification of those structures; they accommodate to information which others manage by way of cognitive repression. The result would be what Piaget has labeled "augmentative equilibration," "an important form of re-equilibration which does not lead back to a previous state, but to a better adaptation" (Inhelder, 1982, p. 42). If creatives are more adept at attaining augmentative equilibrations, this might account for their disposition toward conflict followed by subsequent resolution and integration. Conflict, complexity, ambiguity, and anomaly, whether arising internally or from the environment, are less of an imposition and more of a challenge for the creative person.

When asked to define creativity Piaget replied, "it is to build a structure that is not preformed, neither in hereditary nor in social environment, nor in the physical environment" (Evans, 1973, p. 124). Piaget's writings on the development and modification of structures suggest that accommodation is the principal mechanism in the formation of

novel structures. Attending to that which is discrepant with existing structures and then using that data to reorganize all relevant information is the mechanism through which novel structures are attained.

According to Piaget (1970), both assimilation and accommodation are present in virtually all activity, though "their ratio may vary" (p. 708). Given that assimilation and accommodation are seen as balancing forces in the organism's interaction with environmental events, it is the central hypothesis of this investigation that for creative individuals, the scales are tipped in favor of accommodation. Consequently creatives are easily seduced into a state of disequilibrium and ultimately are able to achieve better equilibriums. What others have referred to as "sensitivity to defects," "recognition of disturbing elements," and "preference for disorder and incompleteness" could all be subsumed under an inclination toward disequilibrium: creatives are, in a sense, more vulnerable to environmental events.

Insofar as Piaget is viewed as a nomothetic theory of cognitive development, one might question the appropriateness of applying Piagetian theory to creativity, an essentially idiographic line of inquiry (Barron, 1969). Attempts to relate Piagetian theory to questions of individual differences have generally focused on age variations in the attainment of the various developmental

stages (e.g., Elkind, 1971; Zigler, 1978), a question which receives little note in the voluminous writings of Piaget. Nevertheless, Piagetian theory is inextricably intertwined with a theory of creativity. Within the genetic epistemological perspective of Piaget, knowledge is a continuous reconstruction, hence novelty and invention are always involved (Royce, Coward, Egan, Kessel & Mos, 1978). Furthermore, while never emphasizing the role of individual differences, Piaget concurred with Bringuier's (1980) assertion that "everyone has his own style of accommodation" (p. 50). Moreover, Piaget (1970) has noted that although assimilation and accommodation are both present in all cognitive activity, the relative contributions of the two may vary across individuals.

This investigation does not aspire to propose a novel theory of creativity, nor to present a radical departure from Piagetian theory, only an elaboration of the theory of creativity implicitly (and, in recent years, explicitly) presented in the writings of Piaget and his cohorts. Although Piaget may be more readily identified with a concern for the ontogenetic growth of knowledge, his writings over the last decade or two contain numerous references illustrating the link between his views on cognition and the processes involved in creativity at every developmental level.

Piaget (1972) describes his undertaking as genetic epistemology, an endeavor which has as its central purpose the study of "the origins of various kinds of knowledge, starting with their most elementary forms, ...up to and including scientific thought" (p. 15). This characterization suggests that the issue of creativity is not peripheral to the writings of Piaget, rather, it is of primary importance. According to Gruber (quoted in Bringuier, 1980), "Piaget is the psychologist who has done the most to develop a theory of creativity" (p. 67).

If you consider creative thinking as a development that takes a long time and brings forth new ideas, it is very similar to the process of the child constructing his world, his thoughts, and his ideas, because the child does not learn simply what the adult tells him, he reinvents. It's a kind of creativity. (p. 67)

Inhelder (1982) has noted the emphasis Piaget placed on disequilibrium in his later writings. For both the preoperational child and the creative scientist, disequilibrium represents a cognitive obstacle to be surmounted. "In working to overcome obstacles, the subject elaborates his own schemes and creates new instruments to fill the gaps" (Inhelder, 1982, p. 412). When the environment does not provide sufficient disturbance, the creative individual may turn attention inward, seeking disequilibrium among schemes, for "it is the nature of the ingenious creator to invent new problems, even if reality does not offer new obstacles for him to conquer" (p. 412).

Piaget states that the effects of nonbalance and the quest for augmentative equilibriums are evident "at all levels, in the early development of intelligence in the child as well as in scientific thought" (Piaget, 1970, p. 709). Piaget elaborated on the relevance of his writings on equilibration to the study of creativity in an interview with Bringuier (1980):

I used the example of the infant, but it's also true for the scholar and the scientist. You have a theory: that's an assimilatory scheme. You can adapt it to very diverse situations.... The adjustment of the assimilatory scheme to all these situations is accommodation. (p. 43)

It is interesting to note, for example, that Piaget refers to the process of decentration and the development of object permanence accomplished by the child between twelve and eighteen months of age as a "veritable 'Copernican Revolution'" (Piaget, 1970, p. 705). Clearly, for Piaget, the child's acceptance of the independent existence of objects and the scientist's revolutionary discoveries invoke the same fundamental processes. Both necessitate overcoming what Piaget (1973) refers to as "the basic obstacle to progress" (p. 135), egocentrism.

Looking toward the latter end of the developmental continuum, Piaget (1972) utilizes the history of astronomy to illustrate the concept of scientific progress as an ongoing battle with egocentrism: "The whole history of astronomy is one of successive liberations from successive

centerings" (p. 82). Each new discovery or theory represents an augmentative equilibrium, it too containing egocentric elements, albeit more refined than in the previous equilibrium. The egocentric components of the new equilibrium, however, only become evident when the new equilibrium is, in turn, disturbed.

Piaget has also taken up the course of developments within the field of physics. Einstein's elucidation of the relativity of time in space is presented as another striking example of de-centering. Piaget (1970) presents a possible explanation for Einstein's accomplishment where others had failed. Piaget discusses how the theory of relativity developed through the process of accommodation. He speaks of the French mathematician and statesman, Poincaré, as having narrowly missed discovering the theory of relativity due to what amounted to a failure of accommodation to Riemannian geometry "because he thought there was no difference between expressing (or translating) phenomena in the 'language' of Euclidian or Riemanian [sic] geometry" (Piaget, 1970, p. 709). Einstein, in contrast, utilized the construct of "Riemanian space as an instrument of structuration, to 'understand' the relations between space, speed, and time" (p. 709). For Einstein, Riemannian geometry produced a disequilibrium which eventually led to an augmented equilibrium inclusive of the theory of relativity, whereas for Poincare either no disequilibrium

was produced in the confrontation with Riemannian geometry, or the disequilibrium was resolved via inversion. Unlike Poincaré, Einstein was able to accommodate to Riemannian geometry and thus was able to generate the augmented equilibrium that is modern physics.

Coming from the other side of the fence, the physicist Bohm (1965) has also observed parallels between the developments in science and Piaget's theory of cognitive development. In fact, Bohm is one of several physicists who has shown an interest in Piaget as a philosopher of science. (Other physicists who have collaborated with Piaget include Rafel, Illia, Correeras, Prigogine, Garcia, and Rolando [Bringuier, 1980]). Bohm suggests that Piagetian theory has relevance for the study of the history and development of all sciences, but for astronomy and physics in particular. He points to Einstein's theory of relativity and the Piagetian construct of de-centering as two manifestations of the necessity for "taking into account the special point of view and perspective of the observer" (p. 223). Bohm concurs with Piaget's contention that the principles of cognitive development are pertinent to the study of scientific progress, and hence to the study of individual creativity: "The most abstract and general scientific investigations are natural extentions of the very same process by which the young child learns to come into perceptual contact with his environment" (p. 223).

More recently, several of Piaget's collaborators have begun to explore in greater detail the theory of creativity alluded to in Piaget's writing. Gruber, for example, has attempted to utilize Piagetian constructs in studying creative thinking as manifested in the history of science. Gruber's work is significant in that it is the first publication to specifically examine the expression of creativity within a Piagetian framework. Gruber is interested in the mechanisms by which significant original ideas emerge and are disseminated. His case study approach illustrates how the development of the theory of evolution can be viewed as having arisen through the process of equilibration.

In the forward to Gruber's (1981) biographical study of Darwin, Piaget described Gruber's undertaking as the application of the principles of genetic epistemology "to the development of the theories of a great scientist" (p. vii). "Gruber has the great merit of showing us that we face this question in the creative work of a genius as well as at the beginnings of mental development which is itself a creative process" (p. viii).

Gruber is concerned with what Piaget (cited in Bringuier, 1980) refers to as "the principal problem in science today" (p. 36), the genesis of structures. Gruber (1981) views the emergence of a new idea, not as an isolated event, "but a change in the properties of some larger mental

structure of which it is a part" (p. 248). For Gruber, the process of constructing a new theory is a matter of altering the impinged schemes in response to new data in order for those schemes to be capable of assimilating that data. The alteration of the scheme to attain consistency with the new idea is, of course, a process of accommodation.

Gruber's exposition of the development of new ideas reveals the delicate balance between the ongoing processes of assimilation and accommodation:

The personal knowledge packed into an abstract idea is put there by the growing person himself, through his own activities, assimilating what he can into existing structures and thereby strengthening them, occasionally noticing anomalies that require the revision of these structures to accommodate experiences that would otherwise not find a stable place. (p. 254)

Elaborating schemes is generally a matter of assimilating additional relevant information into existing schemes. However, schemes are generally too circumscribed to incorporate radically new ideas without some substantial modifications of those structures. Consequently, the very same structures which are necessary for understanding any presenting stimulus may inhibit the veridical assimilation of that stimulus if it is inconsistent with those structures. Gruber indicates the possible consequences of this paradox for scientific inquiry:

The working scientist cannot do without the ability to assimilate what is already known. He needs this not only in order to get started on his scientific career, but daily in the lifetime pursuit of it. On the other hand, overgrown respect of what is

known and too much time spent mastering it lead only to sterile pedantry. (p.72)

The limitations imposed by assimilation are partially checked by the process of accommodation. Through accommodation, oversimplification can be avoided and schemes can be made consistent with conflicting data. It would appear, however, that accommodation also has its limits. Schemes are essentially conservative in nature. As the foundation of organized thought and activity, schemes satisfy the need to preserve order and continuity. Adaptation occurs through virtually unceasing moderate alterations, but extensive overhauls can be destabilizing and are resisted. Therefore, it often happens that "observations which might require change are either neglected or assimilated into existing structures. Thus, even in the face of objective novelty, the existing structure inhibits its recognition, inhibits change" (Gruber, 1981, p. 115). Or, in the words of Piaget (cited in Bringuier, 1980), "when the individual--a child or sometimes even a scientist--constructs a concept or theory, especially a theory, he unconsciously represses what doesn't work" (p. 87); "one doesn't want to recognize what doesn't fit nicely into the system" (Bringuier, 1980, p. 87).

The significance for creativity and scientific progress is apparent. The tendency to avoid information which conflicts with a given theory or scheme will serve to

maintain that scheme, but may do so at the expense of novelty, discovery, and creativity. Conversely, a prerequisite to creativity would seem to be an inclination to seek out and engage cognitive conflict, to accommodate to discrepancy by modifying or revamping one's cognitive structures. Creative individuals seem to be more capable of accommodating to information which others reject, using the discrepant information to achieve an augmentative equilibrium. Their affinity for perturbations and their ability to reconcile cognitive conflict without compromising new, discrepant information may enable creatives to achieve a structuring of information which is inaccessible to less creative individuals.

Gruber's biography of Darwin reveals the preoccupation of one indisputably creative scientist with incongruity and discrepancy. Gruber notes that Darwin was keenly aware of the "tendency to forget unpleasant events such as facts or ideas opposed to one's cherished theories" (p. 239). Moreover, Darwin actively sought to avoid this pitfall in his own endeavors "by immediately writing a memorandum about any such point" (p. 239). Furthermore, Gruber's work illustrates the extent to which Darwin was totally absorbed with the one incomplete aspect of the theory of evolution as he proposed, namely, the source of genetic variation. Lacking the knowledge of genetics previously explicated by Mendel, Darwin was unable to explain the means through which

individual variations occur and new species are generated. According to Gruber, Darwin's concern for the mechanisms of inheritance was one of the primary reason for his hesitance in publishing the theory of evolution. Although Darwin's ideas had been virtually fully developed for a number of years, he delayed publishing until prodded by Wallace's announcement of his intent to publish. Rather than indulging in the ubiquitous habit of ignoring or minimizing ambiguities, Darwin was engrossed with the anomalies he perceived in his theory of evolution. He exemplified the willingness to accommodate to discrepant stimuli and the near obsession with disequilibrium thought to characterize the creative individual.

Both Gruber (1981) and Bohm (1965) noted the similarities between Piaget's works and T. S. Kuhn's theory of scientific revolutions. An attempt will be made in the section that follows to further explore that relationship.

Creativity, Normal Science, and Scientific Revolution

Briefly summarizing, Kuhn (1970a, 1970b) offers a theory of scientific progress in which notions of linear accumulation of information are rejected in favor of a series of stages through which all scientific disciplines are said to pass. At the heart of Kuhn's theory is the paradigm, the prevailing theory or perspective that serves to organize and define a scientific discipline. The paradigm represents both the defining elements of a discipline and the specification of its parameters. Kuhn refers to the stage during which a paradigm is in operation as a period of "normal science," a stage which is characteristic of sciences most of the time.

Once the paradigm is firmly established, it is the implications of the paradigm that are examined and tested, not the paradigm itself. The paradigm becomes a given; the objective of scientists working within a paradigm is to flesh out the ramifications suggested by the paradigm. The job of the scientist is to be an efficient "puzzle solver," the puzzles being posed, addressed, and answered within the language peculiar to the paradigm. The paradigm specifies implicitly the methodologies which will be considered legitimate, and the questions which are worthy of investigation. Since only those questions suggested by the paradigm can be considered, the vast majority of findings

are consistent with the paradigm, as well. The occasional inconsistency is generally thought to represent methodological flaws or shortcomings or is ignored altogether.

Eventually the course of normal science produces anomalies and inconsistencies with the paradigm that cannot easily be dismissed. The result is a renewal of debate focusing on the paradigm itself. Alternative theories then vie for acceptance. Kuhn refers to this battle as the period of "revolutionary science." If the prevailing paradigm continues to be unable to account for the anomalous data, an alternative theory will eventually replace it and attain pre-eminence. In order to be accepted, the new, competing paradigm must account for the anomalous data as well as much, though not necessarily all, of what its predecessor encompassed. A return to normal science follows the revolutionary phase, until marked anomalies become generally apparent once again.

Kuhn's theory of scientific revolutions appears to be in many respects analogous to Piaget's theory of equilibration. In fact, Piaget (1972) has himself noted the similarities between his own work and that of Kuhn. Piaget states that both theories represent attempts to account for "novel syntheses" in the generation of knowledge. The paradigm of Kuhn serves many of the same functions as the

scheme of Piaget: both provide structure and organization to existing information, as well as a framework within which additional information is acquired and integrated; both delimit what novel ideas can be entertained, and, in so doing, determine "the range of the knowable unknown" (Kessen, 1966, p. 102).

Normal science as depicted by Kuhn proceeds in a manner congruent with the process of assimilation as described by Piaget: new information consistent with the structure of current knowledge is acquired without the new information modifying the organization of the previously existing knowledge to any significant degree. Revolutionary science, on the other hand, corresponds to the accommodation to discrepant data, in that the process of acceptance of the new, incongruous data goes beyond mere accumulation of additional information and requires a reorganization of the cognitive structures:

Contrary to the prevalent impression, most new discoveries and theories in the sciences are not merely additions to the existing stockpile of scientific knowledge. To assimilate them the scientist must usually rearrange the intellectual and manipulative equipment he has previously relied upon, discarding some elements of his prior belief and practice while finding new significances in and new relationships between many others.... The old must be revalued and re-ordered when assimilating the new. (Kuhn, 1976, p.42)

Both the revolutionary period and the process of accommodation can be seen as self-corrective mechanisms acting in response to anomalous or discrepant stimuli

(Gruber, 1981). For both Kuhn and Piaget, the recognition of significant anomalous events results in the adaptive reorganization of cognitive structures. "Produced inadvertently by a game played under one set of rules, their assimilation requires the elaboration of another set" (Kuhn, 1970a, p. 52). Thus the consequences of attending to seemingly trivial anomalies are potentially great. As Smith (1969) observed, "throughout the history of science men have become famous simply by refusing to ignore small 'nuisances' that most of us would have brushed aside" (p. 177).

There are, of course, some significant differences between the perspective of Kuhn and that of Piaget. One of the more salient distinctions concerns the frequency of encounters with anomaly or discrepancy. Scientific revolutions are relatively rare events resulting in a totally revamped discipline. Accommodation is ubiquitous by comparison and may involve major modifications to the scheme, as in the case of Einstein's development of the theory of relativity, or may result in only minor, perhaps inconsequential, alterations to the scheme.

Nevertheless, the parallels between Kuhn's theory and Piagetian theory are numerous and striking. Moreover, Piagetian theory--particularly when construed as a theory of creativity--may have relevance for what some have seen as a limitation of Kuhn's theory of scientific revolutions. Much criticism has been leveled on Kuhn's theory regarding the

origins of a revolution, for if the paradigm is as imposing, monolithic and restrictive as Kuhn claims, how could any competing paradigm ever hope to gain a foothold (Feyerabend, 1970; Lakatos, 1970; Watkins, 1970)? While Kuhn does not address this issue at great length, he (Kuhn, 1970b) does suggest that individual differences are, in part, responsible for the eventual overthrow of paradigms. According to Kuhn (1976), prerequisite to "discovery and invention [are] that flexibility and open-mindedness that characterize, or indeed define, the divergent thinker" (p. 42). Scientific revolutions are not possible without individuals possessing those qualities which characterize the divergent thinker. But while divergent thinking and attention to anomaly may be necessary for the advancement of science, Kuhn does not consider these traits, nor the individuals possessing them, to be sufficient. As Marx (1976) observed, "not all scientists need be equally creative" (p. 269). Although it appears that creativity is closely related to the deployment of disproportionate quantities of attention toward perceived anomalies, and that the perception of anomalies is a key component in scientific revolutions, it would be undesirable, nonetheless, for all scientists to be overly concerned with anomalies. The vast majority of all anomalies encountered by the scientist are trivial and lead nowhere (Kuhn, 1976). Their pursuit would be fruitless and would divert scientists from their more

mundane, more quotidian tasks within normal science. If, as Kuhn believes, most of the business of science occurs within the parameters of normal science, then it would be disadvantageous to have more than a small percentage of the scientists within a discipline concerned primarily with paradigmatic anomalies. Yet without a cadre of creative individuals sensitive to anomaly, scientific revolutions could not occur.

It may be somewhat tautological to proclaim that creative individuals are necessary for scientific revolutions, as Kuhn seems to have done. However, Kuhn may have achieved some significant insight into the nature of creativity in so doing. Like Bohm, Kuhn's principal interest lies not in the nature of creativity as such, but in the course of scientific progress. Yet the relevance of Kuhn's theory for the study of creativity (and vice versa) is apparent: to the extent that creativity is responsible for advances in science, the two concerns are isomorphic. Kuhn suggests that individual differences in creativity are manifested in the tendency to attend to, and to make sense of, anomalous information which most others overlook. Those inclined to disregard anomaly contribute to the continuing accretion of data during periods of normal science, while those who pursue anomaly lay the groundwork for future scientific revolutions, and occasionally succeed in inducing a revolution.

Coming from radically different perspectives, Kuhn and Piaget have both reached the conclusion that a salient aspect of creativity, a characteristic which seems to be fundamental for the fruition of all major scientific developments, is the capacity to identify anomalies or events discrepant with expectations and then use those data to achieve a more complete, more veracious organization of previously acquired information. This interpretation of Kuhn and Piaget is congruent with the literature on creativity cited above, as well. In addition, this interpretation of their respective theories may serve to elucidate an element common to each of the studies cited, namely, the disposition of the creative individual to attend to and accommodate to anomalous stimuli (i.e., stimuli discrepant with one's expectations). Nonconformity, openness to experience, attraction to the disconcerting--all the correlates of creativity cited in the first section--can be, at least theoretically, subsumed under the construct of a superior ability possessed by creative individuals to accommodate to perturbations.

In the following sections, two subtopic areas within creativity research will be reviewed. These two areas have been included here because research in each has produced a mini-theory which serves to illuminate some aspect of

creativity. After each review an attempt will be made to relate the mini-theory to the Piagetian theory of equilibration.

Creativity and Schizophrenia

This chapter addresses the reported behavioral commonalities of creatives and schizophrenics. It is hoped that a discussion of the similarities and differences between creatives and schizophrenics will help to clarify the distinctions between high and low creative individuals. The first section reviews the literature on the relationship between creativity and schizophrenia. The second section details some of the specific behavioral characteristics manifested by both creatives and schizophrenics.

The Concomitance of Creativity and Schizophrenia

Consideration of the relationship between creativity and psychopathology has been a recurrent phenomenon in psychology. Perhaps the earliest known proponent of an association between creativity and psychological disorder was Plato, who viewed the "creative process as possession by divine madness" (Rothenberg, 1978, p. 172). Similar sentiments were expressed by Dryden in the seventeenth century in what may be the best known quote on the subject: "Great Wits are sure to madness near ally'd; And thin partitions do their Bounds divide" (1681/1958, p. 221). The

first systematic examination of the topic appeared toward the end of the nineteenth century with the publication of Lombroso's The Mind of Genius in 1891. Like his intellectual predecessors, Lombroso asserted that genius and "mental aberration" were concomitant. Lombroso is noteworthy, however, in that he was the first to support his position with empirical data (Cropley & Sikand, 1973), and because he generated intense interest in the subject, precipitating a "veritable flood" of books on the relationship between genius and insanity (Andreasen, 1978). Chief among his critics was Jacobson (1912) who argued that genius and insanity were diametrically opposed (Cropley & Sikand, 1973).

Research conducted in the twentieth century has tended to support Jacobson's position, although that support has not been unqualified. Not before the middle 1960's was creativity per se examined directly in relation to psychological disorder. Prior to that point in time, the relationship between creativity and psychological disorder was examined only indirectly via constructs such as "giftedness," "genius," or "eminence." Terman's longitudinal study of gifted children (Terman & Oden, 1959) offered substantial evidence that gifted individuals tended to be less susceptible to mental health problems than the population at large. Terman's work served to undermine the stereotype of the gifted child as deficient in some other

area. It should be noted, however, that Terman found the extremely intelligent individuals in his population (IQ above 170) to be prone to adjustment difficulties, a finding reported by Hollingsworth (1942) as well. Terman's study has been criticized for having an overrepresentation of middle- and upper-class individuals, and for reliance on IQ as the sole criterion of giftedness. Furthermore,

while Terman's study seems to indicate that there is a negative correlation between genius defined as high IQ and psychiatric illness, it has also indicated that people with high IQ's are not necessarily artistically or scientifically creative. (Andreasen, 1978, p.3)

It is therefore inappropriate to draw conclusions as to the relationship between creativity and psychological disorder on the basis of Terman's work.

A more recent investigation (Goertzel & Goertzel, 1962) reported findings similar to those of Terman. A biographical survey of "eminent" individuals indicated that although eminent people often exhibited unusual and eccentric personality characteristics, psychotic breakdowns were uncommon.

Despite accumulating evidence that neither position is tenable in its original form, the two extreme positions put forth by Lombroso and Jacobson at the turn of the century have not faded away entirely. In one camp is Challem (1978) who laments that "it has not been uncommon to observe a creative person degenerate to a schizophrenic state in which

creative expression cannot be accomplished" (p. 272). The opposite extreme is represented by Schubert and Bion (1975) who contend that the "seemingly apparent similarities between some creative people and the mentally ill are superficial and unfounded" (p. 226).

Polemics notwithstanding, the majority of recent investigations on creativity and psychological disorder espouse a more complex view of the relationship between the two constructs. The trend in recent theoretical papers and research studies (e.g., Stein & Heinze, 1960; Dykes & McGie, 1976) has been to recognize "that creativity and pathology may have certain characteristics in common, but that the creative individual is nonetheless clearly discriminable from the psychotic" (Cropley & Sikand, 1973, p. 462). Before considering the nature of the similarities and differences between creativity and schizophrenia, two other hypothesized links between creativity and psychological disorder will be discussed.

Consistent with previous literature, Andreasen and Cantor (1975) found no incidents of schizophrenia in an investigation of successful writers. They did, however, detect strikingly high rates of alcoholism, cyclothymic personality disorder, and affect disorder as compared to a control group matched for age, education, and sex. While further research and replication are called for, the findings are intriguing, particularly so when viewed in

light of recent research into the personality characteristics of the depressed. Lewinsohn, Mischel, Chaplin, and Barton (1980) have found depressed individuals to have more realistic self-perceptions than controls. There is also evidence that the depressed are more accurate in the recall of feedback (Nelson & Craighead, 1977) and in judgements of contingency between their own responses and obtained outcomes (Alloy & Abramson, 1979). Perhaps creative individuals are able to use their forays into depression as sources of information about themselves and the world around them that are not commonly available to others; that they possess a characteristic which is a liability in the general population but which seemingly enhances veridical perception in creative individuals. One might speculate that the potential benefit which some seem able to derive from depressive episodes may be related to an ability to accept information which others would repress or ignore. In the state of depression defenses are down and one may be more likely to accommodate to information which might otherwise be too threatening or disturbing.

Consideration of this area will necessarily be limited to the speculative level until further research is undertaken.

A second area of inquiry has focused on possible genetic links between creativity and psychopathology. Such a link was first postulated by Galton (1892) who observed higher than usual rates of mental illness in the families of

geniuses. More recently, a study of the relatives of manic-depressives and schizophrenics in Iceland found a disproportionate number of those relatives to be of "superior intellectual or leadership capacity" (Karlsson, 1970). Conversely, in the Andreasen and Cantor (1975) study, the relatives of creative writers exhibited "a much higher familial prevalence of affective disorder" (p. 42) than those of a control group. Two adoption studies also point to a possible genetic link between creativity and psychopathology. In a sample of normal children placed for adoption by their schizophrenic mothers, Heston (1966) found a much higher rate of creative interests or hobbies. McNeil (1971) found a much higher rate of psychiatric illness in the biological parents of creative people than in their adoptive parents. The rate for the biological parents of the highly creative group was also higher than the rates for either the biological or adoptive parents of a moderately creative group. Studies demonstrating a genetic association between creativity and psychopathology have led to speculation that the nature of the relationship may be analogous to that between malaria immunity and the occurrence of sickle cell anemia; that is, creative behavior may be the adaptive manifestation of an otherwise maladaptive genetic predisposition (Hamer & Zubin, 1968; Jarvik & Chadwick, 1973; Dykes & McGhie, 1976).

Next, behavioral manifestations of the reported

similarities between creatives and schizophrenics will be considered.

Behavioral Similarities and Differences Between Creatives and Schizophrenics

Hasenfus and Magaro (1976) have noted that the theory of creativity offered by Mednick is essentially the same as his theory of schizophrenia: both involve flattened associative hierarchies resulting in unusual associations. There is a growing body of empirical data that suggests the attention deployment strategies of creatives and schizophrenics are similar and that both differ from those of "normal" individuals. Creatives and schizophrenics have in common wide ranging attention which apparently results in a wider sampling of environmental events (Dykes & McGhie, 1976; Cropley & Sikand, 1973). Both tend toward overinclusion on categorization tasks (Hasenfus & Magaro, 1976) and both emit unusual word associations (Cropley & Sikand, 1973; Hasenfus & Magaro, 1976). Furthermore, creatives and chronic schizophrenics are characterized by higher than normal basal levels of arousal and a preference for complex and ambiguous stimuli (Hasenfus & Magaro, 1976). Creative artists resemble schizophrenics in that both exhibit poor smooth pursuit eye movements, a trait which has been considered indicative of nonvoluntary attentional style

(Frost, 1981). In the early research on staccato eye movements, Ditchburn (1955) discovered that vision is impossible without the regular movement of the eyes. Ditchburn reported that when subjected to a constant visual stimulus, the nerve cells of the eye quickly "accommodate" to that stimulus. One might speculate that perhaps the comparatively rapid eye movements of creatives reflect the greater accommodative ability of creatives, both in the physiological sense depicted by Ditchburn and in the psychological meaning put forward by Piaget.

As was noted above, however, creatives are easily discriminated from schizophrenics. How then do creatives and schizophrenics differ in information processing? At least two differences in basic processing mechanisms have been proposed. One hypothesized difference relates to the ability to selectively screen out overabundant stimuli. It may be that the creative individual is able to focus on the central or relevant aspects of the environment and screen out the peripheral when this is necessary (Dykes & McGhie, 1976). In other words, in schizophrenics, wide ranging attention deployment is involuntary and inflexible, while in creatives this same expansive attention is under control and employed only when appropriate. The schizophrenic is debilitated by an attentional mechanism "which precludes him from inhibiting irrelevant stimuli" (Dykes & McGhie, 1976, p. 51) whereas the creative individual has the ability to

retain and utilize stimuli which may appear to be irrelevant to others (Dellas & Gaier, 1970).

A second difference which has been suggested is that creatives and schizophrenics differ in their ability to process the abundance of information to which they are exposed as a result of their wide ranging attention deployment. The "cognitive economics" (Michel, 1979) of creatives and schizophrenics differ; creatives are better prepared to deal with the flood of information to which we are all exposed, a flood "which must somehow be reduced and simplified to allow efficient processing and to avoid an otherwise overwhelming overload" (p. 741).

How can this pattern of similarities and differences among normal, creative, and schizophrenic groups be conceptualized within a Piagetian framework? At some level these characteristics must reflect variations in the equilibrative process. Differences in the efficiency or manner of processing information would reflect differences in assimilation, accommodation, or, taken collectively, in adaptation. Adaptation consists of the ongoing interaction between assimilation and accommodation. Upon first inspection, adaptation may seem a more appropriate construct for differentiating normal, creative, and schizophrenic profiles than either assimilation or accommodation taken singly. With regard to the differences between creatives and normals, the adaptation construct does have a certain

prima facie appeal. We tend to think of creatives as exhibiting superior cognitive abilities, a view which is consistent with a global superiority in processing, i.e., with differences in adaptation. But as Kuhn indicates, that superiority is relative and situation specific. In his analysis of the advantages and disadvantages of the characteristics of creative individuals, Kuhn concludes that the disadvantages far outweigh the advantages except under unusual circumstances. As indicated, one would expect differences in adaptation to be categorically advantageous. To equate creativity with adaptation would therefore place it at odds with the opinions expressed by Kuhn.

Moreover, while one might hypothesize that differences between creatives and normals are congruent with the adaptation construct, the hypothesis would seem unable to account for the similarities and differences between those two groups and schizophrenics. One would not wish to suggest that schizophrenics are superior to normals in adaptation, yet schizophrenics exhibit some of the same characteristics thought to differentiate creatives from normals. Therefore, any hypothesis attempting to account for the pattern of similarities and differences among creatives, normals, and schizophrenics must be more specific, more circumscribed than is adaptation.

Is it possible that one of the two components of adaptation, either assimilation or accommodation alone,

might provide a sufficient and more parsimonious explanation for the attentional similarities and differences among creative, normal, and schizophrenic groups? As with adaptation, it is difficult to see how assimilation can be invoked to account for schizophrenic characteristics. Certainly one would not wish to suggest that schizophrenics have the ability to assimilate more information than can normal individuals. Furthermore, the construct of assimilation does not suggest any explanation for the obvious disparities between creatives and schizophrenics. It does not reconcile the apparent paradox of a behavioral characteristic which seems to be adaptive in creatives and debilitating in schizophrenics. Moreover, there appears to be little logical justification for associating assimilation with creativity. If assimilation involves taking in information into existing schemes, then an individual difference component would seem to imply an ability to take in a larger quantity of information. But is there any basis for hypothesizing that the amount of stimuli one assimilates has any direct bearing on creativity level? The quantity of usable information one assimilates would seem to be more directly related to definitions of intelligence than of creativity.

Indeed, it may be that individual differences in assimilation can be equated with intelligence, in general, and that accommodation is more pertinent to level of

creativity. Intelligence and assimilation can both be seen as dependent on the store of information available and on the ability to acquire additional information. Creativity and accommodation both seem to involve the seeking out and embracing of information at variance with one's expectations and beliefs.

This is not to say that assimilation is divorced from the creative process (nor that creativity is independent of intelligence). Assimilation is an integral part of creativity, as it is in all cognitive activity. Data which is not assimilated has no meaning for the individual. But it is individual differences in accommodation, not assimilation, that appear to be most directly related to creativity level.

The issue of quantity of stimulation experienced must still be addressed if accommodation is to be put forth as an explanation for all of the reported characteristics of creative individuals. And, if the quantity of stimulation experienced is more directly related to intelligence than to creativity, how is it possible to account for findings such as those associating creativity with openness to experience and hyperarousal? Certainly the idea of "openness to experience" is not meant to suggest that creatives are open to all stimuli. Attention and perception are inherently selective processes. Only a small proportion of environmental events can be attended to and processed. Nor

does "openness to experience" necessarily imply that creatives are able to experience more than others. Instead, it may be that creatives differ in the kind of experience to which they are "open" and others are not. Specifically, creatives are open to perturbations, to disequilibrium-producing events which others are inclined to avoid or minimize.

It may also be the case that apparent differences in quantity of data experienced may actually be an artifact resulting from differences in the ability to incorporate perturbations. Because of their ability to accommodate to information which others cannot entertain, creatives may appear to take in more stimuli than normals, when, in fact, it is the nature of the stimulus and not the quantity of stimuli that differentiates creatives from normal individuals. Thus the effects of individual differences in accommodation could easily be misattributed to assimilation. But it is not possible to support the reverse claim; the quantity of stimuli cannot provide a satisfactory explanation for the range of stimuli engaged, i.e., for differential attention to disequilibrium-producing stimuli. One may take in vast quantities of data, particularly when selective processing factors are involved, without encountering significant perturbations. Consequently, the construct of accommodation may be seen as a more parsimonious explanation of creativity than any construct including references to assimilation.

Moreover, assimilation is, to some extent, contrary to the interpretation of creativity contained herein. As stated previously, creativity involves attending to and utilizing information which others overlook or reject because it is inconsistent with the present state of their cognitive structures. In contrast, "any scheme of assimilation tends to feed itself, that is, to incorporate outside elements compatible with its nature into itself" (Piaget, 1977b, p. 7). Therefore, there is no reason to suspect individual differences in the process of assimilation to be associated with creativity.

It would appear that neither assimilation nor adaptation is able to provide an adequate explanation for the observed similarities and differences between creatives and schizophrenics. The discussion will now turn back to accommodation, examining whether or not the process of accommodation can be used to elucidate the pattern of similarities and differences among creative, schizophrenic, and normal groups without relying on any individual difference component in the process of assimilation to bolster the argument.

It was noted above that one would not wish to attribute to schizophrenics the ability to assimilate more than can normal individuals. Similarly, how can it be that schizophrenics accommodate to information unavailable to

others? Inhelder (1976a, 1976b) and Schmid-Kitskis (1976) have noted the peculiarities in the equilibrative processes of "pre-psychotic" children: their "regulation of activity is particularly discordant and does not lead to stable acquisitions" (Schmid-Kitskis, 1976, p. 254). Perhaps the schemes of schizophrenics are so diffuse and ill-formed that there is little with which "discrepant" or "irrelevant" stimuli can conflict. Stimuli that would be dissonance producing for other individuals may encounter little resistance from the nebulous cognitive structures of schizophrenics.

On the other hand, there is no reason to believe that the cognitive structures of creatives are in any way limited or impaired. On the contrary, the schemes of creatives are more flexible, better able to accommodate to incongruity than those of the less creative. This again suggests that the differences between the attentional characteristics of creatives and schizophrenics in comparison with normal groups may be less related to the quantity of stimuli experienced than to the degree of discrepancy or apparent irrelevancy of a stimulus with respect to the operative schemes. Low creatives tend to avoid stimuli which conflict with existing structures, perhaps from a realistic fear of undermining or overwhelming those structures. Schizophrenics fail to avoid discordant stimuli, possibly because their cognitive structures are already confounded. Creatives

actively seek discrepant stimuli and attempt to integrate it with their schemes, making the necessary modifications to those schemes. Schizophrenics and creatives differ from normal groups in that both give greater attention to apparent irrelevant or incongruous data. What differentiates creatives from schizophrenics and normals is the ability of creatives to structure and utilize the incongruous, to synthesize it with pre-existing structures, thereby achieving augmentative equilibrations.

Both creatives and schizophrenics are exposed to an abundance of discordant information, relative to normals. In Piagetian terms, it would appear that both are allured by disequilibrium but that only the creatives are able to go on to achieve augmentative equilibration, whereas the schizophrenic may be unable to reestablish any equilibrium. Only the creatives are able to accommodate to and assimilate the perturbations resulting from constant disequilibria. In schizophrenics, the extreme sensitivity to stimuli "is not matched by an equally extraordinary performance of [the] central processing apparatus" (Lehmann, 1966, p. 406). What is overwhelming to the schizophrenic may be the intellectual fodder of the creative.

Attention Deployment and Creativity

Putting aside creative and schizophrenic similarities for the moment, research examining differences in the attentional processes of high and low creative individuals will be considered next. An attempt will be made to utilize the theory of equilibration to account for the unusual attentional characteristics found in studies of creative individuals.

The preceding discussion suggests that, in addition to differences between creatives and schizophrenics, there are fundamental differences between creative and less creative individuals, and that these differences relate more directly to basic cognitive and perceptual processes than to mere dispositional or stylistic characteristics.

Creative people view the world and react to it unlike most of their peers do, not because they are eccentric and strange, but because they process information differently. (Martindale, 1975, p. 50)

The contention advanced in the section that follows is that the differences in information processing characteristic of creatives result from an ability to accommodate to unexpected or seemingly unrelated information which enables creatives to utilize and interrelate more information than can less creative individuals. Studies utilizing a variety of methodologies and deriving from diverse theoretical positions add credence to the

proposition that creative individuals utilize more information from their environment than do less creative people. In a study of nursery school children, Ward (1969) found evidence that creative children performed better on an ideational fluency task in a cue-rich environment than in a more austere testing room. The performance of less creative children, on the other hand, was not enhanced by the cue-rich testing environment.

Glover, Zimmer, and Bruning (1980) examined passages written by creative and noncreative undergraduate students. After reading an essay, subjects were asked to write a summary of the essay and a "flight of fantasy" based on the essay. Both the summary passages and flight of fantasy writings of the creative subjects were found to contain more "logical intrusions" and fewer "incorrect intrusions" than the writings of noncreative subjects. Logical intrusions were defined as "sentences that were logically congruent with the passage but that contained information not directly expressed in the essay" whereas incorrect intrusions were "sentences not logically congruent with information presented in the passage" (pp. 94-95). Glover et al. concluded that creative individuals are more likely to relate new, incidental information to existing schemata than are noncreative individuals.

Two separate studies with undergraduate students as subjects suggest that creative individuals make better use

of category information in the solution of anagram problems than do less creative subjects. Rainwater (1964) provided subjects with problems solving sets (e.g., "some of the words will be animals and others will have to do with eating") prior to presenting them with the anagrams. Creativity was assessed using both the Remote Associates Test (RAT) (Mednick & Mednick, 1967) and tests from the Guilford battery (GB) (Guilford, 1971). Results indicated that high creatives are more adept at set utilization than low creative subjects, even with the effects of anagram solving ability per se statistically controlled. Differences in set utilization between high and low creative males were greatest with the RAT employed as the measure of creativity, whereas the GB was the better discriminator of set utilization in females. Rainwater suggests that the superiority of the creative subjects may be a product of an ability to maintain multiple hypotheses.

Mendelsohn (1976) obtained results similar to those of Rainwater in a partial replication. The solution of anagrams by creative male subjects was enhanced by category information, however category information did not increase the total number of anagram solutions generated by mid- or low-creative subjects. Mendelsohn used the RAT as a measure of creativity and, as in the Rainwater study, the RAT was more strongly related to utilization of category information by males than by females.

In addition to anagrams from the two sets specified, Mendelsohn included an equal number of anagrams that were from neither set--what he refers to as "neutral" anagrams. Knowledge of category information was manipulated; one group of subjects was informed that some of the words would be drawn from the two categories mentioned, and another group of subjects received no category information. Mendelsohn found that, in general, the knowledge that some of the anagrams were from either of two categories inhibited the solution of neutral anagrams. Subjects who received category information solved more anagrams from the respective categories than did subjects without such information. However, informed subjects solved fewer neutral anagrams than did uninformed subjects, resulting in an equal number of total solutions for the two groups. Mendelsohn found support for his hypothesis that creative subjects would be less likely to overlook the neutral anagrams than less creative subjects. He concluded that creatives are able to simultaneously search the two categories for the anagram solution, and to consider alternate solutions as well. Mendelsohn interprets the results as indicative of a greater attentional capacity in creatives. Creative individuals, according to Mendelsohn, are able to entertain multiple, simultaneous streams of consciousness, an ability which allows them to "acquire in retrievable form more information from the environment"

(p. 361) than less creative individuals.

A variation of Mendelsohn's interpretation of the results that is equally consistent with the data is that creatives are more facile at rapidly shifting the focus of attention. Unlike the simultaneous streams of consciousness theory, the concept of rapidly shifting attention in creative people is also consistent with research cited above indicating that both creatives and schizophrenics exhibit a greater sensitivity to stimuli than "normal" individuals. The research of Frost (1983), in particular, on smooth pursuit eye movements in creative artists suggests the occurrence of rapid attentional shifts in creative individuals.

Creativity and Incidental Learning

The construct of incidental learning is another area that has attracted the attention of researchers in creativity. Logically, incidental learning would appear to be related to creativity and the deviant attentional styles of creative individuals. Incidental learning would seem to represent a permutation or an extension of the theory that creatives are hypersensitive to environmental events. The suggestion is that high creatives are more likely than less creatives to 1) detect significant but nonsalient environmental events, and, 2) to process and integrate those

events in such a manner as to allow for later recall and utilization.

Laughlin (1966) has noted the similarity between incidental learning and Mednick's theory of creativity:

results would seem to indicate that creativity and incidental learning involve the same basic underlying process of bringing apparently irrelevant or unrelated ideas into contiguity or association so that the relationship between them is strengthened. (p. 119)

Using the RAT, Laughlin found significant differences among creativity groups on a measure of incidental learning. High creatives outscored medium and low creative groups, even with IQ employed as a covariate. In a large replication study (Laughlin, Doherty, & Dunn, 1968), creativity and intelligence scores were each used as dependent measures in separate ANCOVA's. Creativity was significantly related to both incidental and intentional learning with IQ as a covariate. Similarly, IQ was significantly related to both incidental and intentional learning with creativity score as a covariate. Creativity, however, was found to be the better predictor of incidental learning whereas IQ was the better predictor of intentional learning.

The principal limitation of the Laughlin studies lies in the distinct similarities among the measures employed. On the RAT, subjects are presented with sets of three words and instructed to find another word that is somehow related to each of the other three. On Laughlin's intentional learning task, subjects were presented with sets of six words and

words and asked to identify the concept associated with four of the six in the set. Following the intentional learning task, subjects were presented with the four words exemplifying each concept, asked to recall the two words from the set not associated with the concepts, and asked to identify the concept linking each of these word pairs. It is possible that the apparent intercorrelations observed among creativity, intentional learning, and incidental learning are actually a product of overlap in the means of measuring the three variables, rather than any commonalities among the underlying constructs.

Much of the research on incidental learning has attempted to subdivide the construct into two more specific aspects of attention deployment, peripheral incidental learning and focal incidental learning. In a study by Mendelsohn and Griswold (1966), for example, subjects were first presented with a printed list of words to memorize while another group of words was playing on a tape recorder. Subjects were instructed to concentrate on the printed list. Following the memorization task, subjects were presented with an anagram solving task. Unbeknownst to the subjects, ten of the solution words were contained in the previously memorized list of printed words, ten were on the tape recorded list of "interference" words, and the remaining ten were words the subjects had not encountered in the

memorization task (i.e., neutral words). Thus "focal incidental learning" was operationally defined as the number of anagram solutions from words on the printed list to which subjects had previously been instructed to attend, while "peripheral incidental learning" was the number of anagram solutions from words on the taped "interference" list. In each case, the number of "neutral" anagram solutions was used as a covariate to control for anagram solving ability per se.

Results of this line of research have been inconsistent and occasionally contradictory. Mendelsohn and Griswold (1964) found the use of peripheral cues in solving anagrams to be significantly related to creativity though no significant relationship was found between the use of focal cues and creativity score. The reverse pattern of results was obtained, however, in a study by Dewing and Battye (1971): creativity was significantly related to the use of focal cues but not to the use of peripheral cues. In a study by Mendelsohn (1966), data on two samples were analyzed separately. Creativity was associated with the use of focal cues in both samples but in only one of the two samples was use of peripheral cues associated with creativity.

A problem common to each incidental learning study cited above is the possible confounding effects of IQ. Mendelsohn and Griswold attempt to address this issue by

including vocabulary level as an independent variable in their analyses. Unfortunately, because vocabulary and the RAT (the measure of creativity used in this study) are correlated, it was not possible to evenly divide subjects into equal cells. Instead the authors chose to selectively eliminate from consideration the scores of some subjects "in such a fashion as to produce maximum differentiation in mean RAT scores among the three levels" (p. 427), a procedure which may well have resulted in the artificial inflation of the effects attributable to creativity.

Dewing and Battye (1971) rejected the RAT for use in their study, noting that it "was particularly unsuitable for the Mendelsohn and Griswold study because of the possible [confounding] effects of vocabulary level" (p. 215). And yet the creativity measures selected by Dewing and Battye for use in their study can be similarly faulted: both the Torrance Test of Creative Thinking (TTCT) and the GB are correlated with IQ (TTCT: Yamamoto, 1965; Wallach, 1968, 1970; Wodtke, 1964; GB: Guilford, 1971b; Guilford & Christenson, 1973; French, 1978). Furthermore, the Dewing and Battye study contained no means of controlling for the effects of IQ.

It should be noted that Mendelsohn and Griswold used the Barron-Welsh Art scale (BWAS) as an additional measure of creativity. The BWAS is a test of artistic preferences that correlates with creativity criteria but is apparently

unrelated to IQ (Wallach, 1971). Scores on the BWAS were associated with the use of neither focal nor peripheral cues.

Another issue relating to the findings cited above concerns the efficacy of the operational definitions of incidental learning utilized in each of these studies. Equivocal findings with regard to the relationship between creativity and incidental learning may stem, in part, from the bifurcating of the construct into the separate components, focal and peripheral incidental learning. Each of the derivative constructs appears deficient in some significant respect. Barron (1981) suggests that the creative individual has a "tendency to use, or at least attend to, more and seemingly irrelevant information than is necessary for the solution of the problem at hand" (p. 461). If Barron's statement is an acceptable definition of incidental learning, then the term focal incidental learning would appear to be an oxymoron; when the subjects are instructed to focus their attention on a particular stimulus the resultant learning is not incidental. At the time of acquisition the learning which occurred was clearly intentional, not incidental. What has been called focal incidental learning may actually be a measure of transfer of training, where previous knowledge is applied to a new task in which the relevance of the previously learned material to the task at hand is not readily apparent.

The lack of consistent findings with regard to peripheral incidental learning may also relate to definitional confounds. In all of the studies cited above, subjects were instructed to attend to one list of words and ignore another list. The peripheral cue words were characterized as "interference" or "distractor" words. When those instructions are considered in light of similarities and differences in the attentional styles of creatives and schizophrenics, the ambiguities of the peripheral incidental learning construct become evident. As alluded to previously, an hypothesized distinction between creative and schizophrenic attentional styles is that, unlike schizophrenics, creatives may possess the ability to screen out overabundant stimuli when necessary. Perhaps some of the creative subjects in the incidental learning studies respond to experimental demands and exercise their ability to screen out stimuli, stimuli which have been explicitly labeled as "distractors."

Mendelsohn and Lindholm (1972) attempted to evaluate

Like the literature on creativity and schizophrenia, research on the attentional styles of creative subjects indicates that creative individuals have a greater receptivity to environmental events. Furthermore, high creatives appear more adept than low creatives in integrating new information into existing structures and in later accessing and utilizing that information. In other words, viewed in the light of Piagetian theory, research on the attentional styles of creative individuals suggests that creatives are more easily prompted into a state of disequilibrium by seemingly incidental stimuli than are noncreatives, and that creatives are then able to accommodate to the incidental stimuli overlooked by less creative individuals. The terms employed in the attention deployment literature may be readily translated into Piagetian terminology. The categories of words utilized by Mendelsohn et al. may be considered schemes, words within the respective categories are scheme words which subjects attempt to assimilate into designated schemes. The neutral words constitute stimuli which are discrepant with the schemes. Results indicate creative subjects are more capable of accommodating to the discrepant stimuli than are the less creative subjects.

Hypotheses and Predictions

An attempt was made in this investigation to address some of the issues raised by the Mendelsohn studies within the framework of Piagetian theory. The intention was to provide a more direct testing of the hypothesis that creative thinking is characterized by higher than average levels of disequilibrium seeking and accommodation. It was hypothesized that creativity is related to measures of accommodation but not to measures of assimilation. An auxiliary hypothesis was that creative individuals are more capable of adjusting their personal assimilation/accommodation balance than are less creative individuals.

Specific Predictions

It was predicted that creativity would be related to two distinct operational measures of accommodation. First, subjects attempted to recognize three different types of briefly presented words. It was predicted that there would be no differences between high and low creative subjects in the recognition of words from a designated scheme, a task involving the assimilation of those words into a prescribed scheme. It was anticipated, however, that high creatives would exceed low creatives in recognizing those words which

are related to the scheme and in recognizing unrelated words, tasks requiring accommodation to stimuli of moderate and high levels of discrepancy, respectively, with the prescribed scheme. Secondly, it was anticipated that creativity would be related to the rate at which subjects accommodated to an illusion-producing stimulus.

The ability to adjust the assimilation/accommodation balance was tested by systematically varying instructions to subjects. When instructed to focus on scheme words and not to be distracted by other words, it was expected that creative subjects would respond appropriately and that differences between high and low creative subjects would be minimized or eliminated altogether. In contrast, when given instructions intended to maximize accommodation ("give equal attention to all the words"), it was expected that high creative subjects would respond to the instructions by recognizing more related and unrelated words than in the previous condition. The performance of low creative subjects, on the other hand, was expected to be relatively constant across conditions, indicating an inability to respond to the instruction and thereby alter the assimilation/accommodation balance.

One additional instructional condition served as an intermediate set between the conditions described above. These instructions emphasized assimilation without excluding accommodation; subjects were instructed to give their

attention primarily to scheme words without overlooking the other words. This instructional set was included because it may possibly possess the greatest external validity of the three conditions. This condition may be analogous to the situation encountered by a scientist faced with new information relevant to the body of knowledge already familiar to the scientist. The task then is to relate the new information to the structure of existing knowledge without excluding the possibility that valid data may be encountered which is discrepant with expectations or with existing knowledge. The expectation was that, as in the "exclusive" attention condition, high creative subjects would recognize more related and unrelated words than would less creative subjects.

Method

Subjects

Subjects were 45 male and 59 female undergraduate students, volunteers recruited from an introductory psychology course. Subjects received course credit for participating in the investigation. Forty-nine percent of the subjects were freshmen, 30% were sophomores, 14% were juniors, and 9% were seniors. One subject was a nonmatriculating student. Sixty-two percent of the subject were under 20 years old. Eleven percent were above 21 years old.

Subjects were told that they were participating in a perception study and that one part of the study would involve attempting to recognize words when flashed very briefly on a video screen. Subjects were debriefed after all had completed the tasks. (Copies of the consent and debriefing forms are contained in Appendix D.)

Materials

Word recognition task. A word recognition task was derived in part from methodologies employed by Mendelsohn in his investigations into the relationship between creativity and individual differences in attention deployment. In the Mendelsohn studies, subjects were required to solve anagram

problems. A simple word recognition task was used in this investigation rather than an anagram solution task in order to minimize the effects of verbal skills.

Muller-Lyer task. A means of presenting the Muller-Lyer illusion on a CRT using the Apple II computer was developed. A complete listing of the program is given in Appendix E.

Creativity Tasks. Four tests adapted by Wallach and Kogan for assessing ideational fluency were used as a measure of creativity. The Alternate Uses task and the Similarities task were used to measure verbal creativity, while the Line Meanings and Pattern Meanings tasks were used to measure figural creativity. As in previous investigations (e.g., Wallach & Wing, 1969), subjects completed three items selected from each of the four tasks.

Because correlations between creativity test scores and IQ frequently approach the correlations between creativity tests and creativity criteria, and because IQ is often correlated with the creativity criteria to the same extent, it is necessary to question the extent to which "creativity" tests are merely tapping general intelligence (Wallach, 1968, 1970; French, 1978). The Wallach-Kogan tests (W-K) seem to have overcome many of the methodological shortcomings plaguing other creativity tests. Several

studies have demonstrated the factorial validity of the W-K tests. Analyses show test results separate into two factors, one verbal and one figural, and that these factors are distinct from intelligence test scores (J. Ward, 1967; Cropley & Maslany, 1969; McKinney & Forman, 1977). Wallach (1971) cites several studies using the W-K measures that found no relationship between the creativity measures and various IQ measures while significant intercorrelations among the creativity measures were obtained. This has held true for fifth graders (Wallach & Kogan, 1965a, 1965b), for college students (Wallach & Wing, 1969), for seven and eight year olds (W. Ward, 1968), and for South African high school students (Lindemann & Fullagar, 1975). A few studies have reported low correlations between the W-K tasks and IQ, most of which may be attributed to deviations from the testing procedures recommended by Wallach and adoption of more "test-like" administrative procedures (e.g., Vernon, 1971; W. Ward, 1975).

The W-K tasks have also accumulated adequate validity data. While there is no relationship between IQ and extracurricular accomplishments in high school, there are significant correlations between scores on the W-K tasks and many nonacademic attainments (Wallach & Wing, 1969). Positive correlations between the W-K tasks and numerous other creativity criteria have been found (Rotter, Langland, & Berger, 1971; Bartlett & Davis, 1974; Wallbrown &

Huelsman, 1974).

The internal consistency of the W-K tasks is substantial. Wallach and Wing (1969) report inter-item correlations in the middle .70's, Vernon (1971) reports a split-half reliability of .87, and Cropley and Maslany (1969) report KR20 reliability coefficients of between .82 and .87 for the respective tasks. Kogan and Pankove (1972) offer evidence for the long term stability (from the fifth to the tenth grade) of the W-K tasks as well as evidence for the predictive validity of the tasks. McAllister and Kulberg (1983) also found both figural and verbal measures to be moderately stable over an 18 month interval.

As Wallach (1971) observed, the W-K tasks are a measure of ideational fluency, not of creativity per se. Wallach warns of the dangers of equating the two constructs; correlates of ideational fluency are not necessarily correlates of creativity. Nevertheless, the reliability and validity data on the W-K as an indicator of certain creative abilities compare favorably with other measures of creativity.

Procedure

Word recognition tasks. The word recognition tasks were administered to subjects individually through the use of an Apple II computer. (The program utilized is presented

in Appendix E). Subjects were exposed to an example list of 12 words prior to the start of the experimental trials. Ten of the words were then flashed on the screen, one at a time. The duration of the flash was gradually decreased to allow subjects to become acclimated to the procedure. The duration of the flash for the first example word was 100 msec. The duration was decremented through the eighth word at which point the 27 msec period used in the experimental trial was reached. If a subject failed to reach a criterion level of at least eight words correctly identified, then the example was repeated. If the criterion was not reached on the third attempt, then the experimenter proceeded to the experimental trials, regardless. Seventy-six percent of the subjects reached the criterion level on the first trial. An additional 13% reached it on the second trial and 8% on the third trial. Five percent of the subjects had not reached the criterion after the third trial.

In the experimental trials, subjects viewed lists of 48 words for a time of sufficient length to allow the reading of each word (approximately 40 s). Lists were composed of singular, concrete nouns which occur more than one time per million words in written English. Three categories of words were equally represented in each of three lists. One category consisted of words within a scheme that was identified for the subjects prior to the presentation of the list. An example of a scheme which was utilized is "words

that are the names of animals." Prior to the presentation of the list, subjects were informed "that some of the words are related to each other; they are the names of animals."

A second category of words included in each list was words that were in some way associated with the specified scheme but that were not actually members of that scheme. For the "words that are the names of animals" scheme, examples of related words included "hoof," "tail," and "wool." The third category of words consisted of words which were unrelated to either the scheme or to each other.

Words which were related to the scheme were intended to represent stimuli which were moderately discrepant with the identified scheme, whereas the unrelated words functioned as stimuli which were significantly discrepant with the scheme. The degree of discrepancy with the scheme should determine the relative ease or difficulty a subject has in accommodating to the word; in general, subjects were expected to accommodate more readily to the related words than to the unrelated words. Perception of the scheme words, on the other hand, should be primarily a function of assimilation.

The three categories of words were matched for frequency of occurrence in written English using frequency data compiled by Carrol, Davies, and Richman (1971). (Lists of the words and their respective frequencies are presented in Appendix C). In addition, each set of 16 words within a

list contained the same number of total letters. Words were arranged within the list according to a predetermined random order which was the same for all subjects.

Following the presentation of the list of words, subjects viewed a series of 36 words--12 from each of the three categories specified above--which were flashed on the screen, one at a time. Each word was visible on the screen for approximately 27 msec. After the presentation of a word the subject attempted to say the word aloud. An experimenter recorded the response. The subject prompted the presentation of each successive word by pressing the button on a hand-held game control paddle. The hand-held control permitted subjects to position themselves at whatever distance from the screen they found most comfortable. Words were flashed in a predetermined random order which was independent of the order in which the words initially appeared in the list. The successive use of similar word recognition procedures in a variety of studies suggests that the task is sufficiently reliable for significant results to be obtained (Rumelhart & Siple, 1974).

The presentation of each flashed word was preceeded and superseded by a mask, as is often done in word recognition studies (Kahneman, 1968). The mask consisted of three lines of 11 X's enclosed within a box and centered over the flashed word. It was visible on the screen for

approximately 54 msec in both the preceeding and superseding presentations.

Each subject repeated the experimental procedure three times, utilizing a different word list for each trial. In addition to the "words that are the names of animals" scheme, one of the remaining two lists was based on a "words that are the names of foods" scheme, and the third list was based on a "words that are the names of vehicles" scheme. The order in which the lists were presented to each subject was randomly determined.

The three trials differed in the instructions which subjects were given regarding how the subject should attend to a list when it was presented. Instructions were read to the subject by the experimenter prior to presentation of the respective word lists. Under one condition, subjects were instructed to give equal attention to the related words and to the unrelated words when viewing the list. Furthermore, subjects were told that an equal number of the flashed words were drawn from the related and the unrelated words. Under a second instructional condition, subjects were instructed to give most of their attention to the related words and less to the unrelated words. They were told that more of the flashed words were drawn from the former and fewer from the latter. Under the third instructional condition, subjects were instructed to give all of their attention to the related words as they viewed the list, since most of the

flashed words would be selected from the related words and only a few would be taken from the unrelated words. In fact, an equal number of scheme words, related words, and unrelated words were flashed in each of the three trials.

The three differing sets of instructions were included to obviate the confounding of incidental learning and screening ability evident in previous investigations. The first and third conditions were comparable to the two conditions employed in the Mendelsohn and Lindholm (1972) study except that in present investigation subjects received their instructions prior to their initial exposure to the words. The second condition was intended to establish a less equivocal incidental learning set, whereas the third condition was used as a measure of screening or limiting of attention in response to instructions. The order in which each subject received the instructional sets was randomly determined. A complete rendering of all instructions for the word recognition task is presented in Appendix D.

Muller-Lyer task. Following the attention deployment task, subjects were exposed to 30 successive presentations of the Muller-Lyer illusion. The left line segment of the illusion was of constant length for all trials. The initial length of the right line segment was randomly determined for each trial. Subjects used a game control paddle to adjust the length of the right line segment until it appeared to be

equal in length to the left line segment. The subject then pressed a button on the paddle, recording the length of the line as set by the subjects and generating a new right line segment of randomly determined length. Subjects typically completed the thirty trials in five to ten minutes.

The rate at which the effects of the illusion diminished over trials was expected to be inversely correlated with creativity. This "slope score" was also expected to be negatively correlated with the other measures of accommodation employed in this investigation, namely, the number of Related and Unrelated words recognized.

Creativity tasks. After the completion of the word recognition task and the Muller-Lyer task, subjects were given the creativity tasks. Subjects were given instructions on completing the tasks and directed to another room. Enclosed instructions indicated that the tasks had no time limit: "Work on each question for as long as you like. Feel free to go back and forth from one question to another until you decide you are finished." An attempt was made to emphasize the confidentiality of test results and to minimize any similarities or connections between the creativity tasks and test-like situations. Previous research indicates that the validity of the W-K tasks is enhanced when the tasks are administered without time limits and given in what appears to be a nonacademic, nonevaluative

context (Boersma & O'Bryan, 1968; Vernon, 1971; Van Mondfrans, Feldhusen, Treffinger, & Ferris, 1971; Hargreaves, 1974; Wallbrown & Huelsman, 1975). Subjects were reminded of the importance of working on the tasks independently and of not discussing the tasks with any other subjects who had not yet completed the tasks.

Results

Results pertain to the relationships among three sets of variables: the creativity scores, the attention deployment data, and data from the Müller-Lyer task. The first section addresses the relationship between creativity and attention deployment; the second section examines the relationship between creativity and performance on the Müller-Lyer task. Finally, the relationship between attention deployment and performance on the Müller-Lyer task is considered in the third section.

Creativity and Attention Deployment

Initially, a 2 X 3 X 3 X 3 analysis of variance (Winer, 1971) was used to assess the relationship between creativity and attention deployment. The four factors were sex, creativity level, instructional set, and word-type, with the latter two being repeated measures.

Scores from the Wallach-Kogan tasks were summed to obtain a total creativity score. High-, Medium-, and Low-creative groups were identified by trichotomizing the distribution of total creativity scores. Cutpoints were chosen so as to produce groups of approximately equal size without separating individuals with identical scores into different groups. The mean total creativity score was 62.23

with a standard deviation of 21.41. Means and standard deviations for the resultant groups were 86.30/18.09, 57.97/4.67, and 42.06/6.71 for the High-, Medium-, and Low-creative groups, respectively.

The three Word-type categories were Scheme words, Related words, and Unrelated words. The three instructional conditions were Equal attention, Primary attention, and Exclusive attention. Cell means and standard deviations of the word recognition scores for each combination of these three factors are presented in Table 5 of Appendix B.

Preliminary analysis revealed no main effect for sex and no significant interaction between sex and any other factor or combination of factors. Consequently, data were pooled into a 3 X 3 X 3 analysis of variance. Homogeneity of variance across cells was assessed using Hartley's F-max test (Winer, 1971). Results indicated the presence of heterogeneous variances: $F\text{-max}(27,33) = 4.95, \underline{p} < .01$. Consequently, a data transformation was attempted. Squaring the scores resulted in adequate homogeneity of variance across cells: $F\text{-max}(27,33) = 2.51, \underline{p} > .01$. Cell means and standard deviations for the squared scores are presented in Table 1. The summary table of the 3 X 3 X 3 analysis of variance on the transformed scores is presented in Table 2. A significant main effect for word-type was found along with a significant interaction between word-type and instruction. Neither the main effect for creativity nor any of the

Table 1

Means and Standard Deviations
 For Transformed Recognition Scores:
 Total Creativity X Word-Type X Instruction

		<u>Creativity Level</u>		
		Low	Medium	High
		(n = 32)	(n = 35)	(n = 33)
EQUAL ATTENTION	Word-Type			
	Scheme	100.40 (41.06)	92.00 (33.65)	97.82 (39.39)
	Related	85.50 (44.10)	74.43 (38.04)	79.61 (37.11)
PRIMARY ATTENTION	Unrelated	68.66 (42.29)	55.77 (32.61)	62.85 (43.91)
	Scheme	105.70 (30.66)	103.20 (35.83)	103.90 (41.02)
	Related	79.88 (41.78)	73.86 (35.88)	86.97 (46.12)
EXCLUSIVE ATTENTION	Unrelated	47.56 (37.24)	46.97 (35.87)	66.21 (34.32)
	Scheme	98.94 (35.30)	93.86 (41.32)	107.20 (29.10)
	Related	78.19 (41.40)	73.97 (41.70)	79.52 (40.82)
	Unrelated	48.16 (36.63)	49.54 (38.28)	68.64 (43.01)

Table 2

Analysis of Variance Summary Table on Transformed Scores:
Total Creativity X Word-Type X Instruction

Source	Sum of Squares	D. F.	Mean Square	F
Creativity	15103.80	2	7551.92	1.00
Error	731439.96	97	7540.62	
Instruction (I)	783.01	2	391.50	0.36
I X C	6327.40	4	1581.85	1.46
Error	210010.67	194	1082.53	
Word-Type (W)	279480.00	2	139740.00	182.53**
W X C	3741.12	4	935.28	1.22
Error	148521.23	194	765.57	
I X W	6937.21	4	1734.30	3.13*
I X W X C	4226.62	8	528.33	0.95
Error	214985.75	388	554.09	

* $\underline{p} < .05$

** $\underline{p} < .001$

interactions with creativity reached significance at the $p < .05$ level of probability. A priori follow-up tests on the main effect for word-type indicate significant differences for all possible comparisons: Scheme > Related > Unrelated. As expected, all subjects tended to find the Unrelated words most difficult to recognize, and the Scheme words the least difficult to recognize.

Results of the a priori comparisons reveal no significant differences across creativity groups under the Equal attention condition. Under the Primary attention condition, no differences were found in the number of Related words recognized. However, a significant difference was attained in the recognition of the Unrelated words: $F(2, 97) = 3.10$, $p < .05$. The High-creative group recognized significantly more Unrelated words under the Primary attention condition than did the Medium- and Low-creative groups. The latter two groups did not differ significantly.

The powerful effect observed for word-type, along with the significant interaction effect found between word-type and instruction, would seem to account for most of the variance associated with the word-type factor. Hence the chances of detecting a significant interaction between word-type and creativity, or a three way interaction between word-type, instruction, and creativity are minimal. Therefore, an alternative procedure was undertaken to evaluate the relationship between creativity and the

attention measures, one that is less subject to the preemptive influence of the word-type effect within the ANOVA model.

A canonical correlation (Lindeman, Merenda, & Gold, 1980) was performed on the two sets of variables using the P6M program of the Biomedical Computer Programs (Dixon, 1981). The first set consisted of the raw scores from the four creativity tasks: Alternate Uses, Similarities, Pattern Meanings, and Line Meanings. As noted above, Wallach and Kogan (1965a) characterized the former two tasks as tests of verbal creativity while the latter two are described as measures of figural creativity. The second set of measures consisted of the nine attention deployment variables derived from crossing the three word-type levels with the three instructional conditions. Because data on four subjects were incomplete, the analysis was performed with an N of 100 subjects.

One significant eigenvalue was obtained from the canonical correlation (see Table 6, Appendix B). Loadings and Standardized Coefficients for the significant eigenvalue are presented in Table 3. All four creativity variables exhibit at least moderate loadings on the creativity variate. Only Pattern Meanings, however, makes a substantial unique contribution to the determination of the variate.

A different pattern is found for the attention

Table 3

Loadings, Canonical Coefficients, Standardized Coefficients, and R^2 with the Opposite Set for the First Canonical Variate

Variable	Loading	Canon. Coeff.	Standz. Coeff.	Opposite Set R^2
<u>First Set: Creativity Variables</u>				
Pattern Meanings	.996	.1897	1.051	.470*
Line Meanings	.705	-.0173	-0.100	.412
Alternate Uses	.413	.0004	0.003	.374
Similarities	.375	.0076	0.059	.259
<u>Second Set: Attention Variables</u>				
Equal-Scheme	.020	.0288	0.061	.164
Equal-Related	.086	-.1724	-0.427	.184
Equal-Unrelated	.081	.0506	0.153	.258
Primary-Scheme	-.098	-.2712	0.534	.203
Primary-Related	-.084	-.1984	-0.528	.317*
Primary-Unrelated	.409	.2939	0.833	.328*
Exclusive-Scheme	.325	.3477	0.736	.241
Exclusive-Related	-.005	-.3150	-0.863	.143
Exclusive-Unrelated	.385	.2735	0.891	.261

* $p < .05$.

variables. Few of the variables appear correlated with the variate. The exceptions are Unrelated words under both Primary and Exclusive attention conditions, and Scheme words under the Exclusive attention condition. A different pattern is evident when the standardized coefficients of the attention variables are examined, indicating that several of the attention variables are making unique contributions to the attention canonical variate.

In order to further explicate the relative contributions made by the attention variables to the prediction of creativity, a backward multiple regression analysis was employed. The SPSS New Regression procedure (Hull & Nie, 1981) was used with the pairwise deletion of missing data option in effect. The Pattern Meaning score was selected as the criterion measure. Alternatively, the canonical coefficients might have been used to derive a creativity canonical variate score, and to use the score on the canonical variable as the predictor. But the high loading of Pattern Meanings on the canonical variate, coupled with the near zero standardized weights of the other creativity variables, makes this procedure unnecessary. Weighted scores and Pattern Meanings would likely yield the same results in this instance, hence the Pattern Meanings scores were selected for convenience and ease in interpretation.

The multiple R obtained on the prediction of Pattern

Meanings score by the nine attention deployment measures was .44 ($p < .01$). Table 4 shows the regression coefficients for the attention measures. Five of the nine attention variables make significant contributions to the prediction equation. None of the three variables under the Equal attention condition make a significant contribution to the prediction of creativity. The largest weights are for Unrelated words under Primary attention and Exclusive attention conditions. Related words exhibit significant negative weights under the same two conditions, and Scheme words show a positive loading only under the Exclusive attention condition.

Creativity and Performance on the Müller-Lyer Task

Figure 1 illustrates the performance of the three creativity groups over the the 30 trials of the Muller-Lyer task. Scores were averaged over clusters of three trials for ease of presentation and interpretation. The figure suggests that there was some diminishing of the illusion's effect with repeated exposure, as anticipated, but that the pattern of results is nonlinear in nature. A test of trend (Winer, 1971) over the 10 blocks using the analysis of orthogonal components procedure contained in program P2V of the BMD package (Dixon, 1981) bolsters this suspicion (see Table 7, Appendix B). At the $p < .01$ level of probability,

Table 4

Regression Coefficients of the Attention
Variables in Predicting Pattern Meaning Scores

Variable	Unstd Beta	Std Beta	T Value
Primary-Related	-.809	-.38	-2.93**
Exclusive-Unrelated	.679	.407	2.78**
Exclusive-Related	-.759	-.377	-2.54*
Primary-Unrelated	.594	.304	2.51*
Exclusive-Scheme	.683	.268	2.25*
Primary-Scheme	--	--	-1.26
Equal-Related	--	--	-1.02
Equal-Scheme	--	--	-0.55
Equal-unrelated	--	--	-0.53

* $\underline{p} < .05$

** $\underline{p} < .01$

Note. $\underline{N} = 104$.

FIGURE 1
MEAN EFFECT OF MÜLLER-LYER
ILLUSION OVER TRIALS

a quadratic trend is indicated. If a $p < .05$ is adopted, a quintic function defines the line of best fit. Regardless, results of the test of trend strongly suggest that it would be inappropriate to calculate the slope of the line for each subject over all 30 trials since the data are not accurately represented by a linear function.

Rather than calculating a single slope score based on all 30 trials of the Müller-Lyer task, the slope of six separate line segments was calculated for each subject. Each of the resulting six slope scores was based on a five-trial block of the Müller-Lyer task. A high-negative slope score is indicative of a rapidly diminishing effect of the illusion, i.e., rapid accommodation. A slope score of zero indicates no change in the magnitude of the effects of the illusion over the trials evaluated by that particular slope score, i.e., no accommodation. Using the six separate slope scores permitted the comparison of the curves across trials for the respective creativity groups.

A canonical correlation was performed with the four creativity measures constituting one set of variables and the six slope scores serving as the second set. Results of the analysis are detailed in Table 8 of Appendix B. No significant canonical correlations were obtained, indicating no significant differences in the diminishing of the illusion's effect over trials as a function of creativity level.

Attention Deployment and Performance on the Müller-Lyer Task

An additional canonical correlation was performed with the six slope scores again serving as one set of variables. For this analysis, the nine attention measures formed the second set of variables. Results are reported in Table 9 of Appendix B. No significant canonical correlations were obtained, indicating no significant relationship between the attention deployment measures and accommodation to the Müller-Lyer illusion.

Discussion

The two major hypotheses of this investigation will be considered separately in the two immediately following sections. In the first section, findings on the relationship between creativity and the ability to accommodate to discrepant events is discussed. The second section examines the evidence pertaining to the relationship between creativity and the ability to modify one's assimilation/accommodation balance. Results on the Muller-Lyer task are considered in the third section. Finally, the consistency of the results with Kuhn's theory of scientific revolutions is discussed in relation to Piagetian theory.

Creativity and Accommodation to Discrepant Events

The central thesis of this investigation was that creativity is related to an ability to accommodate to stimuli discrepant with one's expectations. Support was found for this hypothesis in that high creative subjects recognized significantly more Unrelated words than did low creative subjects, at least under certain conditions. Thus differences were found in attention given to (and/or the ability to recognize) those stimuli intended to represent the highest level of discrepancy from the designated scheme.

High creative subjects were also expected to recognize more Related words than low creative subjects, words intended to represent a moderate level of discrepancy with expectations. No support was found for this prediction, however. High creatives did not recognize any more Related words than did low creatives. Moreover, Related words exhibited negative beta weights in the prediction of creativity under two of the three instruction conditions and made no significant contribution to the regression equation under the third condition. The results suggest that the association between creativity and attention to moderately discrepant stimuli cannot be appropriately portrayed by a simple, linear relationship.

The multiple regression analysis seems to indicate quite clearly that, under both Primary and Exclusive attention conditions, Related words are serving as suppressor variables. For Related words, zero order correlations with creativity are functionally zero but the beta weights are negative and moderately high. For Unrelated words, zero order correlations with creativity are positive and moderately high. The presence of the suppressor effect suggests that it is not attention to discrepancy, or accommodation to discrepant stimuli, per se which is most directly related to creativity, rather, it is the individual's propensity for the extremely discrepant contrasted with his/her response to moderate discrepancy

which is most predictive of creativity. The difference between the number of extremely discrepant and moderately discrepant stimuli recognized, as opposed to the absolute value of either score, appears to be most significant. It is these differences which distinguish the high creative from the low creative subjects.

Modification of the Assimilation/Accommodation Balance

Based on theories which discuss apparent similarities and differences between creatives and schizophrenics, it was predicted that high creative subjects would be more capable of modifying their assimilation/accommodation balance than the less creative subjects. The expectation was that the less creatives would respond appropriately to instructions requesting that equal attention be given to Scheme words and Unrelated words. Low creative subjects were expected to be unable to make this shift to greater accommodation of discrepant stimuli. Under the Exclusive attention condition, on the other hand, the high creative subjects were expected to minimize accommodation and to maximize assimilation, thereby reducing any differences between the two groups in the recognition of Related or Unrelated words.

In fact, the evidence from the canonical correlation tends to support the opposite conclusion. High creative

subjects appear to have been unaffected by the instructions. Their performance was relatively consistent over the three instruction conditions. In contrast, the low creative subjects do appear to have responded to the instructions. Low creatives recognized more Unrelated words under the Equal attention condition than under the Primary or Exclusive attention conditions.

It would be less than accurate to suggest that high creative subjects responded to the Exclusive attention instructions in an inappropriate manner since they failed to screen Unrelated words under this condition. As per these instructions, the high creative subjects also recognized more scheme words under Exclusive attention instructions than did the low creative subjects. It may have been unnecessary for the high creative subjects to screen the Unrelated words in order to recognize the Scheme words. Perhaps if the task had been more difficult, if it had been more demanding of the subjects' exclusive attention, then screening by the high creative subjects might have occurred.

Sykes and McGhie (1976) suggest that the creative person can readily make the switch to a more assimilative, less accommodative mode "in cases where efficient performance is contingent on a more convergent approach" (p. 55). Apparently, "efficient performance" under the Exclusive attention condition was not contingent on making the switch toward greater assimilation. Indeed, the effects

the literature indicates is characteristic of schizophrenics as well. Moreover, no support was found for the hypothesis that high creatives can screen distracting environmental events, an ability which schizophrenics appear to lack. At least two possible explanations can be advanced for the failure to find an ability to voluntarily control attentional strategy in high creatives. The first, as put forward in the preceeding section, is that the task was not sufficiently difficult for the high creatives to require any modification of attention strategy. Alternatively, high creatives, like schizophrenics, may in fact be deficient in screening ability. This is not to suggest that the highly creative and the schizophrenic are indistinguishable, only that the differences between the two groups may lie in another area, most probably relating to the ability of high creatives to process and integrate the surfeit of information to which they are exposed. There is evidence that, for at least some creative individuals, the controlling of the flood of stimulation is problematic. Martindale (1975) suggests that many creative individuals feel driven to "invoke the muse" through external means in order to "change their level of cortical arousal" (p. 50). Alcohol, drugs, and self-imposed isolation are among the methods reportedly used by high creatives in their efforts to reduce over stimulation.

Unequivocal assessment of the screening ability of

high creative subjects will not be possible before further research has been undertaken. Perhaps a study in which task difficulty is systematically varied would shed further light on the issue.

Findings on the effects of instruction are consistent with the hypothesis that creativity is related to incidental learning. When subjects were given explicit instructions to give equal attention to Scheme and Unrelated words, no differences between high and low creative groups were found. In contrast, high creative subjects recognized more Unrelated words than did low creative subjects when instructions diverted attention from the Unrelated words.

Results of this investigation support Mendelsohn's (1976) conclusion that there is a "link between attentional processes and creative performance" (p. 365), but are inconsistent with the specific nature of the link suggested by him. In a previous study, Mendelsohn and Lindholm (1972) found that although high creative subjects made more use of cues provided in a subsequent anagram solution task than did low creatives, it did not matter whether or not the subjects were explicitly informed as to the nature of the cues (i.e., whether they were incidental or explicit). In terms of the design, a main effect was found for creativity on cue utilization but no interaction between creativity and the nature of the cues was found. Mendelsohn explains the

results in terms of a greater attentional capacity for creative subjects and the ability of creatives to maintain multiple streams of consciousness.

Given Mendelsohn's hypotheses, the predicted outcome of the present investigation should be a main effect for creativity. Greater attentional capacity would result in recognition of more words irrespective of word-type or instructional condition. Likewise, the ability to deploy multiple streams of consciousness would seem to allow one channel for each type of word, producing equally great differences between high and low creative groups across word-types and instructions. Such was not the case. Neither the analysis of variance nor the canonical correlation gives any indication of a main effect for creativity. Instead, the latter analysis tends to suggest an interaction between creativity and word-type, and possibly a three-way interaction among creativity, word-type and instruction.

The contention that the canonical correlation results are inconsistent with a main effect for creativity may require some further explanation. If a creativity main effect were present, one would expect most of the attention variables to exhibit positive, moderate to high zero order correlations with the creativity variate. Moreover, one variable should show a high standardized canonical coefficient and the value of most of the rest should be near zero. A main effect for creativity would indicate that all

nine attention variables were, in essence, measuring the same thing. If this were so, only one variable should make a substantial unique contribution to the prediction of the creativity variate. But, as noted above, the actual pattern of results is quite different. The fact that several variables make unique contributions suggests the existence of interaction effects; the relationship of attention deployment to creativity differs at the various levels of the two factors.

Several reasons can be advanced to account for the discrepancy between the results of this investigation and those obtained in Mendelsohn's studies. Most notable may be the point in time when information regarding the nature of the stimulus words is communicated to the subject. In the present investigation that information was related prior to the subject's initial exposure to the list of words. In Mendelsohn's studies, subjects were informed of the relationship between the stimulus words and the subsequent task only after the list of words had been withdrawn. Perhaps the differences in incidental learning have less to do with the ability to subsequently recognize or recall the stimulus words than with how the words were initially processed. It may be that when creative subjects are told of the role to be played by the Unrelated words prior to studying the list, they are able to structure schemes in a manner that facilitates subsequent accommodation to the

unrelated words. Future investigations might consider using the timing of information dissemination as an independent variable. Manipulating both the timing and the nature of the information received by subjects may provide additional insights into the processes involved in accommodating to stimuli discrepant with expectations.

The canonical correlation analysis appears to have been more sensitive to differences in attention deployment in the present investigation than was the ANOVA model. While this may provoke questions regarding the tendency of canonical correlation to capitalize on chance (Lindeman et al., 1980), there are, nevertheless, several legitimate reasons for the canonical correlation analysis to uncover significant relationships which went undetected by the analysis of variance. First, the powerful main effect for word-type in the analysis of variance reduces the chance of obtaining a significant interaction between word-type and creativity, or a significant three-way interaction between word-type, creativity, and instruction. The canonical correlation, on the other hand, is unaffected by the differences in the words, except to the extent which those differences are related to creativity. Second, much information was forfeited in order to use creativity as an independent variable in the analysis of variance. The canonical correlation utilized the entire distribution of creativity

scores and was therefore a much more powerful procedure. Finally, the creativity measure used in the analysis of variance was obtained by summing subjects' scores on the four creativity tests. Using the summed score is predicated on the assumption that all four creativity tests are measuring the same underlying construct. Both the canonical analysis and previous research on the Wallach-Kogan tasks suggest that this may have been an erroneous assumption. Factor analysis of the tasks indicate the presence of two factors, one tapping verbal creativity, the other, figural (e.g., McKinney & Forman, 1977). The canonical correlation procedure suggests that differences in attention deployment are more closely related to figural creativity than to verbal creativity. Using the hybrid score, "total creativity," may have obscured these differences.

It is unclear why differences in accommodation should be more closely associated with figural than verbal creativity, yet there is some substantiating evidence to suggest that the finding is not a spurious one. In the Dewing and Battye (1971) investigation of the relationship between creativity and incidental learning, nonverbal tests of ideational fluency were found to be more sensitive to differences between high- and low-creative groups than were verbal fluency measures.

It is also interesting to note that Pattern Meanings, the variable which virtually defines the creativity variate

in this study, has the greatest internal consistency of the four creativity tasks (Wallach & Wing, 1969). This suggests that the canonical correlation procedure is utilizing the creativity variable with the greatest potential predictive power rather than merely capitalizing on chance.

Some comments pertaining to the entire population, irrespective of creativity level, are in order. The striking differences in subjects' ability to recognize Scheme words versus Related words versus Unrelated words illustrate the extent to which expectations influence perception. The degree of discrepancy with expectations (i.e., the amount of accommodation required) largely determined the likelihood of the stimulus word being recognized. Though the differences in the recognition of the types of words remain extremely powerful under all instruction conditions, the effect is somewhat mitigated when subjects are given explicit instructions to attend to the Unrelated words.

Given the association between creativity and accommodation, the fact that subjects evidenced more accommodation when instructed to do so suggests intriguing possibilities for intervention. Would training subjects to "expect the unexpected" alter subjects' attention deployment styles? If so, what would the effect be on assessed creativity? Future research might consider the effects of

"accommodation training" on creativity performance.

The Müller-Lyer Task

In considering the relationship between creativity and performance on the Müller-Lyer task, it must be noted that it proved impossible to evaluate the relevant hypothesis in the form in which it was originally stated. It was anticipated that the effects of the illusion would show a linear decrement across trials. Instead, the pattern across trials more closely resembles a curvilinear function. Consequently, the original hypothesis was based on a faulty assumption and was therefore untestable.

The decrement in the illusion's effects over trials--nonlinear function notwithstanding--is consistent with the hypothesis that subjects tend to accommodate to the stimulus over the course of repeated exposures. Yet no evidence was found of any relationship between performance on the Müller-Lyer task and creativity, nor was there any indication of a relationship between attention deployment and Müller-Lyer performance. While the negative results are discouraging they do not invalidate the relationship found between creativity and attention deployment, nor do they necessarily mean that creativity and/or attention deployment are unrelated to accommodation. It is possible for example, for creativity and Müller-Lyer

performance to both be related to accommodation yet still not be related to each other.

It may be that the two constructs are related to different aspects or levels of accommodation. The Müller-lyer may tap accommodative processes which are more purely perceptual in nature while creativity and attention deployment are related to accommodative processes operating more on a cognitive level. Or the accommodative processes involved in creativity and Müller-Lyer performance may differ more in quantity than in kind. The complex interrelationship among creativity and the ability to recognize Related and Unrelated words suggests that the relationship between creativity and the ability to accommodate to highly discrepant stimuli is distinct from the relationship between creativity and accommodation to moderately discrepant stimuli. Perhaps the accommodation occurring on the Müller-Lyer task is of a lesser order than that required in the attention deployment task.

One additional point is worthy of note concerning the Müller-Lyer tasks. Several subjects volunteered information which suggests that the sample population may not have been entirely naive with regard to the nature of the illusion. More than one subject asked whether one should adjust the line so that it appeared equal in length to the standard, or to the point where it would "really" be the same length. The confounding effects of prior knowledge concerning the

illusion may have influenced the results pertaining to the Müller-Lyer in unpredictable ways.

Creativity, Accommodation, and Scientific Progress

Differences between high and low creatives in accommodating to moderate and high levels of discrepancy have implications for Kuhn's theory of scientific revolutions; it may be possible to achieve some synthesis of the developmental perspective of Piaget with the historical orientation of Kuhn. A Piagetian analysis of creativity may help to clarify the role of the individual within the paradigmatic shifts proposed by Kuhn, to clarify the symbiotic relationship that exists between the creative person and his or her discipline.

According to Kuhn (1976), the scientist operating within Normal science does not require high levels of creativity. Instead, the individual needs to possess adequate puzzle solving skills and the ability to elaborate on each successive step suggested by the paradigm. It is interesting to speculate that the ability to attend to moderate discrepant stimuli may correspond to the skills required of the individual engaged in Normal science. Perhaps the puzzle-solving activities of the Normal scientist represent attempts to accommodate to moderate discrepancy, possibly by resolving apparent conflicts within

the operative paradigm, or by elaborating on previously unsuspected aspects of the paradigm. In the process of accommodating to the moderately discrepant stimuli, relatively minor adjustments to the paradigm occur.

Revolutionary science, on the other hand, is dependent on individuals being able to integrate anomalous, unexpected data into an orderly whole; to accommodate to apparently inconsistent findings and synthesize them into a new, more comprehensive theory. Major reorganizations of the scheme/paradigm may be necessary before accommodation to the discrepant data can be achieved.

One implication inherent in this theory of creativity is that the creative process will not always lead to creative product. As Kuhn (1976) suggests, attention to anomaly only leads to advantageous outcomes a small percentage of the time. To the extent to which creativity can be identified with attention to anomaly, it can be seen that creativity is not always productive. Certainly only a small percentage of creative individuals ever realize major scientific accomplishments. Chance and Zeitgeist may be as significant as creative ability in the fruition of discovery. Moreover, creativity can be counterproductive. In their continuing search for perturbations, creative individuals may be routinely distracted by spurious data and inconsequential inconsistencies. As a result, they may become preoccupied with tangents and dead ends. Lakatos

(1970) described numerous instances in the history of science where experiments produced apparently profound evidence at odds with a prevailing theory. Most often these data are later revealed to be in some way inaccurate or misleading. Nevertheless, attention to anomaly appears to be prerequisite to scientific progress. Fostering or tolerating creativity can be seen as an attempt by a discipline to hedge its bets and lay some money down on the long shot. Generally, it will fail to come in. Occasionally, it will pay off big.

The cross-fertilization of Piaget and Kuhn has equal import for Piagetian theory and research. It illustrates the applicability of Piagetian constructs to areas of study which have previously received comparatively little attention within the Piagetian paradigm. It underscores the relevance of Piaget to the study of adult cognition, in general, and to the understanding of the processes involved in discovery and invention, in particular. Furthermore, the synthesis of Piagetian constructs with Kuhn's theory may help to illuminate the considerable room for the expansion of the investigation of individual differences components within Piagetian theory. Thus far, most of the research examining individual differences within a Piagetian framework have focused on the age of attainment of the developmental milestones or on the possibility of modifying the sequence or rate at which stage-specific behaviors

occur. However, Piaget can also be evoked when examining processes which remain constant across developmental stages, that is, the mechanisms of equilibration and adaptation. These are processes which have generally been either embraced or dismissed, but rarely investigated.

The extent to which creativity is defined by accommodation to anomalous events remains to be seen. Certainly other factors beyond those considered in this investigation are involved in the determination of creativity. Furthermore, much additional research is needed to clearly demonstrate this relationship. Nevertheless, the relationship between creativity and accommodation is an intriguing one, one that may help to further illuminate the nature of creativity.

Limitations and Directions for Future Research

This investigation attempted to offer support for a Piagetian theory of creativity. But because the data presented herein represent the work of only a single investigation and because the results can be subjected to alternative explanations, the possibility that the theory is spurious must be acknowledged. Popper (1962) has suggested that theories cannot be proven, only supported or disconfirmed. This investigation offered some preliminary and qualified support for the theory put forward. It remains for subsequent investigations to secure additional support or to reject the theory in favor of an alternative providing a more satisfying and comprehensive explanation of the data.

The problems in attempting to substantiate a theory of creativity may be more difficult to overcome than those faced in other psychological research endeavors. There tends to be a higher level of nebulousness and ambiguity in creativity research than in other areas. It is difficult to attain a high level of precision; defining constructs is problematic and the operational definitions utilized tend to be even less satisfying. When the elusive area of creativity is crossed with the inferred processing constructs put forth by Piaget, the difficulties in specifying operational measures increase exponentially.

In the present investigation, much deliberation went into the selection of acceptable measures of assimilation and accommodation. Several alternative sets were rejected because they failed to adequately distinguish between the two constructs or because their correspondence with the underlying constructs was too tenuous. Nevertheless, the operational measures employed in the present investigation are not above reproach. In part, this issue is inherent in studies attempting to address hypothetical constructs which can only be inferred and not directly observed. The problem is further confounded by the fact that a particular event may be readily assimilated by one individual with minimal structural modifications, while extensive modifications of the scheme may be necessary for another individual to assimilate the same information. Therefore it would appear that the investigator must have some knowledge of the operative schemes as well as of the stimuli to be accommodated to and subsequently assimilated. However, as stated above, this information can only be accessed indirectly, if at all. Because the experimenter has limited information concerning the status of pre-existing schemes, it is difficult, if not impossible to ascertain whether extensive accommodation is necessary for a given stimulus to be assimilated into a given scheme. One way of attempting to gain some control over these ambiguities is by designating or creating schemes. Knowing the parameters of

a scheme permits more accurate assessment of the degree to which various stimuli are discrepant with the scheme. This is the approach that was taken in the present investigation. An attempt was made to delineate schemes through the use of word lists. However, this approach has its own limitations. First, the artificiality of fabricated schemes limits the extent to which results can be generalized. To what extent do the artificially specified schemes resemble the constitution and operation of more naturally occurring schemes? Moreover, there is no assurance that subjects actually develop and utilize the schemes according to experimenter expectations.

One means of attempting to compensate for the limitations of any one measure is to use multiple measures of each construct. Demonstrating the interrelationships among the measures would provide support for the contention that all measures were tapping the same underlying construct. Multiple measures would also provide a means of delineating the range of the relationship between creativity and accommodation. For example, the present investigation suggests that creativity may be most closely associated with a certain type or degree of accommodation, namely, accommodating to information which is severely discrepant with the operative scheme. Accommodating to moderate or low levels of discrepancy appears to be less directly related to creativity. Multiple measures may help to clarify these

relationships. Similarly, a multidimensional approach to creativity may provide a more complete and satisfying treatment of creativity. Two measures each of verbal creativity and figural creativity were used in this investigation. Results suggest that little information was gained over what would have been provided by a single measure of the respective constructs. In future investigations it may be propitious to include only one task from the Wallach-Kogan verbal measures and one from the figural measures, but to also include other reliable measures of creativity. Using an assortment of measures such as self-ratings, ratings of supervisors, advisors, or peers, behavioral checklists, or accomplishment inventories may aid in specifying the aspects of creativity which are most closely associated with creativity. An assumption of the present investigation was that creativity could be treated as a global construct. No distinction was made, for example, between "artistic" creativity and "scientific" creativity. Using a multi-dimensional approach to the assessment of creativity might provide an opportunity to evaluate this assumption. Comparing groups of artistically creative and scientifically creative individuals would provide another means.

The population employed in the present investigation represents an additional limitation. The population was relatively homogeneous with respect to age and education.

Consequently, the generalizability of the results is limited. Moreover, it is difficult to specify exactly what range of creative abilities is represented by this population. The Wallach-Kogan tasks provide no information in this regard; no norms are published: results of this research instrument are intended to be meaningful only with respect to the sample population from which a given subject is drawn. Certainly one would expect some examples of outstanding creative ability within a population predominated by freshmen and sophomores in a state university, but it is not possible to characterize the creative abilities of the sample population as a whole. One might speculate that the population does not possess an inordinate number of individuals of outstanding creative accomplishments, and that perhaps creative abilities are somewhat underrepresented in this group. Perhaps a study which included a larger percentage of demonstrably creative individuals would produce a more distinct pattern of results. The use of extreme groups would be a more sensitive technique, particularly as compared to a sample which may have had a restricted range.

One further concern regarding the sample population relates to the Müller-Lyer task. As noted previously, some subjects indicated that they were not entirely naive with regard to the nature of the Müller-Lyer task. Knowledge of the task may have influenced performance and confounded

results in any of several different ways. Knowledge of the expected effects may have been equally represented across the creativity groups or it may be that the information was utilized differently by the respective groups. Given some understanding of how the illusion operates, a subject may either attempt to compensate for its effects or to respond based on the way the figure "actually" appears. Therefore, the propensity for using knowledge of the illusion's effects is another, independent factor which may have confounded results on the Müller-Lyer task.

As alluded to above, one way of minimizing the limitations of a particular measure is to employ multiple measures of each construct. However, a "shotgun" approach cannot be used to excuse inadequate measures. Modifications of the measures used in the present investigation might have strengthened the connection between the measures and the hypothesized underlying constructs. Evaluating subjects' ability to modify the assimilation/accommodation balance proved particularly problematic. It appears that the tasks, as administered may not have been sufficiently demanding of the subjects' attentional resources. Some subjects were able to identify most, if not all, of the Scheme words and still recognize the majority of Related and Unrelated words when they were presented. The relative ease with which these subjects recognized the words may have undermined the attention instructions; subjects who could readily identify

Scheme, Related, and Unrelated words would have no need to attend exclusively to one type of word. Consequently, they would be less likely to modify their assimilation/accommodation balance in response to instructions.

The problem of the task being insufficiently demanding was not apparent during pilot studies. Then, few subjects approached the ceiling in any of the three word categories. The difference may have been changes made in subject training procedures between the pilot studies and the present investigation. In the former, subjects went through the demonstration exercise only once, regardless of their performance. In the latter, subjects repeated the demonstration if they did not reach the specified criterion. This may have made the subsequent task easier than it was in the pilot studies. It may be desirable to again use the more limited training procedure in future research. Alternatively, reducing the exposure latencies for the words would make the task more difficult and might require subjects to further utilize the instructions given. Another possibility would be to individualize the latencies for each subject. Training trials could be used to determine the exposure time at which a given subject would recognize 50%, for example, of the words presented. Individualizing latencies would eliminate concerns about basal or ceiling difficulties. Of course, individual differences in the

exposure time required to recognize a given percentage of the words is derivative of the ability to perceive flashed words. Therefore, it would be necessary to consider latency differences as a possible dependent measure. However, there is no reason to expect that latency differences in recognizing unselected words would be related to creativity. Consequently, individualizing latencies would be unlikely to influence results pertaining to creativity.

Several alternative hypotheses can be put forth to account for the results obtained in this investigation. Incidental learning and breaking set are two such alternatives. These perspectives are not necessarily mutually exclusive and are, in fact, largely compatible with a Piagetian interpretation of the results obtained. It may be possible to design future research studies so as to evaluate differential predictions associated with the respective theories, however, that endeavor was beyond the scope of the present investigation. Meanwhile, it is possible to assess the relative merits of the three theoretical perspectives in summarizing and explaining existing research and thinking in the field of creativity. In this respect, the Piagetian perspective advanced herein may be more comprehensive and more inclusive. It would seem pertinent to the study of creativity at many different levels, from the creative play of the small child to the

advancement of radically new paradigms within disciplines. The utility of the incidental learning construct appears to be more circumscribed. While its relevance for studying the attentional styles of creatives is clear, its significance for understanding major creative accomplishments seems more tenuous.

The Gestaltist construct of mental set appears similar to that of the scheme in many respects. It is therefore particularly difficult to discuss the relative merits of the respective theories for the study of creativity. However, one significant difference between the two perspectives may be that mental set appears to be a more static construct than is the scheme. Whereas the set can only be sustained or broken, Piaget allows for the modification, differentiation, and integration of schemes. Piagetian theory offers an explanation, not only for breaking set/perturbation detection, but of what may follow--a more complete, more accurate, more veridical scheme.

This investigation served as a preliminary exploration into a Piagetian theory of creativity. Interpretation of results is hindered by methodological shortcomings, particularly those relating to operational definitions of Piagetian constructs. Replication studies using alternative and/or modified operational definitions are called for. Additional research is needed to delineate the parameters of

the theory, perhaps specifying the circumstances where it applies.

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Appendix A

Raw Data

Note: The data are in order according to the following fixed format:

30F2.0/F3.0,X,2F1.0,X,9F2.0,X,F1.0,12F2.0

The first card for each subject contains the data for the 30 trials on the Müller-Lyer task. The second card contains, in order, subject ID, order of trials, and experimenter. The next nine variables are the attention measures. The order for instruction is Equal, Primary, Exclusive. The order for Word-Type is Scheme, Related, Unrelated. Instruction is the slower changing of the two repeated measures. The next variable is sex, followed by scores on each of three items for each of the four creativity tests, Alternate Uses, Pattern Meanings, Similarities, and Line Meanings.

Subject 001

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Subject 119

495246494048494440474448494551514949465143464554505052495048
119 17 080507091005100908 2220905050307060508080509

Appendix B

Tables

Table 5

Means and Standard Deviations on Word Recognition Scores:

Creativity Level X Word-Type X Instruction

		<u>Creativity Level</u>		
		Low	Medium	High
Word-Type		(n = 32)	(n = 35)	(n = 33)
EQUAL ATTENTION	Scheme	9.75 (2.36)	9.43 (1.79)	9.64 (2.26)
	Related	8.81 (2.85)	8.31 (2.34)	8.64 (2.28)
	Unrelated	7.72 (3.06)	6.91 (2.86)	7.27 (3.20)
PRIMARY ATTENTION	Scheme	10.16 (1.63)	9.97 (1.96)	9.94 (2.30)
	Related	8.56 (2.60)	8.26 (2.42)	8.85 (2.99)
	Unrelated	6.25 (2.96)	6.34 (2.63)	7.67 (2.77)
EXCLUSIVE ATTENTION	Scheme	9.75 (2.00)	9.34 (2.60)	10.24 (1.54)
	Related	8.38 (2.88)	8.09 (2.97)	8.61 (2.37)
	Unrelated	6.28 (3.00)	6.17 (3.43)	7.67 (3.19)

Table 6

Summary Table of the Canonical Correlation Between
Creativity Measures and Attention Variables (N = 104)

Number	Eigen- value	Canonical Correlation	Lambda	Degrees Freedom	Chi- Square
1	.2216	.4708	.5638	36	52.72*
2	.1433	.3785	.7243	24	29.67
3	.1212	.3482	.8456	14	15.44
4	.0379	.1948	.9621	6	3.56

* $p < .05$.

Table 7

Test for Trend Over Müller-Lyer Trials (N = 100)

	Sum of Squares	D. F.	Mean Square	F
Trial	3153.16	9	350.35	21.99**
Error	13911.30	8773	15.94	
Linear	2288.37	1	269716.80	361.35**
Error	3816.92	97	39.35	
Quadratic	567.31	1	567.31	23.55**
Error	2336.79	97	24.09	
Cubic	99.71	1	99.71	5.49*
Error	1762.09	97	18.17	
Quartic	94.22	1	94.22	5.56*
Error	1642.51	97	16.93	
Quintic	66.48	1	66.48	6.41*
Error	1006.15	97	10.37	
Sextic	33.77	1	33.77	3.67
Error	892.52	97	9.20	
Septenary	2.48	1	2.48	0.24
Error	1000.50	97	10.31	
Octenary	0.00	1	0.00	0.00
Error	725.77	97	7.48	
Nonic	0.82	1	0.82	0.11
Error	728.03	97	7.51	

* $\underline{p} < .05$ ** $\underline{p} < .001$

Table 8

Summary Table of the Canonical Correlation
Between Creativity Measures and Slope Scores (N = 100)

Number	Eigen- value	Canonical Correlation	Lambda	Degrees Freedom	Chi- Square
1	.1057	.3251	.7772	24	23.32
2	.0763	.2762	.8691	15	12.98
3	.0539	.2321	.9408	8	5.64
4	.0056	.0747	.9944	3	0.52

Note. The first canonical correlation is not significant at the $p < .05$ level of probability.

Table 9

Summary Table of the Canonical Correlation

Between Attention Measures and Slope Scores (N =100)

Number	Eigen- value	Canonical Correlation	Lambda	Degrees Freedom	Chi- Square
1	.1426	.3776	.6538	54	38.25
2	.1113	.3336	.7625	40	24.40
3	.0778	.2788	.8580	28	13.78
4	.0394	.1984	.9303	18	6.50
5	.0250	.1581	.9685	10	2.88
6	.0067	.0820	.9933	4	0.61

Note. The first canonical correlation is not significant at the $p < .05$ level of probability.

Appendix C

Frequencies of Occurrence

In the English Language for the Three

Matched Sets of Scheme, Related, and Unrelated words

Note: Words above the broken lines appear both in the listed words and among the flashed words. Words below the broken lines appear only in the listed words, not among the flashed words.

Set 1: Words That Are The Names Of Foods

<u>Scheme Words</u>	<u>Unrelated Words</u>	<u>Related Words</u>
apple (294)	suit (292)	meal (286)
cheese (236)	court (236)	pan (240)
soup (122)	harbor (121)	stove (122)
potato (30)	ribbon (29)	fork (29)
steak (99)	spout (100)	menu (103)
bacon (515)	meadow (511)	feast (497)
bread (127)	hat (127)	kitchen (128)
turkey (12)	wax (12)	picnic (12)
chili (28)	gutter (27)	spatula (26)
cod (88)	oasis (90)	snack (90)
bean (92)	organ (90)	spoon (92)
cracker (25)	coop (24)	pantry (25)

sausage
(16)
radish
(14)
melon
(16)
prune
(8)

varnish
(16)
falcon
(14)
orchid
(16)
tepee
(8)

toaster
(16)
grocer
(14)
cafe
(15)
grill
(8)

Set 2: Words That Are The Names Of Vehicles

<u>Scheme Words</u>	<u>Unrelated Words</u>	<u>Related Words</u>

auto	grove	pedal
(39)	(39)	(39)
rocket	factory	traffic
(242)	(237)	(242)
jet	mail	motor
(221)	(203)	(198)
bicycle	soup	horn
(182)	(184)	(185)
canoe	hay	pilot
(164)	(171)	(167)
van	hoe	toll
(35)	(33)	(33)
yacht	corpse	bumper
(16)	(16)	(17)
sled	guitar	cargo
(104)	(106)	(106)
truck	army	wheel
(410)	(412)	(418)
taxi	quartz	mast
(43)	(43)	(41)
ferry	flap	car
(41)	(36)	(35)
train	root	gas
(556)	(568)	(583)

---

glider	cocoon	motel
(38)	(34)	(34)
ship	moon	road
(1021)	(1046)	(1106)
bus	plate	station
(345)	(346)	(341)
tractor	scarf	fare
(47)	(50)	(54)

Set 3: Words That Are The Names Of Animals

<u>Scheme Words</u>	<u>Unrelated Words</u>	<u>Related Words</u>
panther (21)	jade (21)	antler (20)
zebra (25)	suite (26)	claw (25)
turtle (104)	lap (105)	feather (106)
cat (620)	cover (604)	tail (620)
mule (76)	brook (76)	paw (77)
camel (72)	novel (71)	pork (74)
fox (163)	porch (168)	roar (167)
tiger (112)	hook (112)	stable (114)
cow (263)	candy (256)	wool (255)
wolf (139)	acid (140)	zoo (139)
pony (210)	tent (208)	bark (204)
moose (52)	marsh (52)	rodeo (52)

---

pig (142)	fort (140)	wing (139)
gopher (11)	wig (11)	hoof (11)
elk (24)	altar (24)	snout (24)
lion (264)	cave (264)	fur (259)

Appendix D

Instructions

Consent Form

This experiment is a study of various perceptual characteristics. It has three parts to it. The first part involves looking at words which will be flashed very briefly on a TV screen and trying to recognize the words when they are flashed. Because this part of the study necessitates watching flashing lights you should not volunteer for it if you are bothered by flashing lights or susceptible to seizures. In the second part of the study subjects will be comparing lines of various lengths and trying to match them for size. The third part will be completing a paper and pencil questionnaire.

The first two parts will take about half an hour altogether. The third part is open ended, it has no time limits. You may spend as much or as little time working on it as you like. Try to leave yourself a good chunk of time for this part though, so you don't have to break away while you are still working at it. You may find the questions fun to answer and not want to leave before you are satisfied that you are done.

We are interested in how people in general perform on these tasks and answer these questions, not in your performance in particular, or that of any other individual. All of your responses will be kept confidential. Only the data on the group as a whole will be reported, not that of any individual. Only the experimenters will see any identifying data or any individual information, not your teachers or your classmates or anyone else.

If you decide to volunteer for this study and come during the scheduled time you will receive ten extra points toward your final course grade. You are free to withdraw from the study at any time if for any reason you chose not to continue. After the results of the study have been compiled you will receive a letter explaining the findings. You will also have a chance to meet with the experimenter at that time if you have any questions or if you desire any additional information. If you decide to participate in this experiment, please sign your name below and return this form.

I agree to participate in the study described above. I understand I may withdraw at any time if I so choose.

Name: _____ Date: _____

Initial Instructions to Subjects

Thank you for volunteering to help out with this study.

Please read the following instructions carefully. The experiment will not begin until you are ready.

In this part of the study, you will first be looking at a list of words on a TV screen. You will be given instructions on how to study the list.

Next, some of the words from the list will be flashed on the screen--very briefly--one at a time. The words will be flashed in the middle of a box. There will be an arrow on either side of the box, pointing to the spot where the word will be. Your job is to try to recognize the word when it is flashed and to say the word out loud.

Remember to be looking right at the area between the arrows as you press the button. Otherwise you might miss the word.

--don't get discouraged if you find you are missing many of the words. The task is difficult and you will not be able to recognize all of the words, but try to concentrate on each one.

--if you have any questions, reread the instructions or ask the assistant for help. When you are ready to start, press the button and the example will begin.

Instructions to Experimenters

- 1) Give the subject a copy of the consent form to read and sign. Subject may choose to leave if he or she would rather not sign. Return signed consent form to designated file.
- 2) Place a check on the list of subjects next to the subject's name to show that the subject came.
- 3) Write the information on the example sheet, including the subject's id# (taken from the list of subjects).
- 4) Give the subject the initial instructions. Answer any questions but try not to give any additional information.
- 5) On the keyboard type "run atten".
Don't forget the space between "run" and "atten" and remember to press the "return" key after typing the words.
- 6) As the subject attempts to recognize the example words, record the responses as either correct or wrong.
- 7) After the last example word, count the number correct. If it is less than eight then press the "y" to repeat the example and record the responses again. If the total correct is eight or more, then ask the subject if he/she wishes to repeat the example. If yes, press the 'y' and record responses again. If no, press the 'n' and go on to the next step. Do not repeat the example more than twice.
- 8) Read the general instructions.
- 9) Read the instruction set indicated by the computer, filling in the word in the blank as indicated by the computer. Do the same for all three sets of instructions.
- 10) Record the order of instructions on the example sheet. Press any key to go on.
- 11) Enter the subject's id# (from the example sheet) onto the computer, as indicated.
- 12) Answer any questions about the second part after the subject reads the instructions on the screen.

13) Add up totals on the first part while subjects are working on the second part.

14) When the subject is done, hand him/her the third part and direct him/her into another room where he/she can work on it.

Instructional Sets Read By the Experimenter

General Instructions (after the example)

Now we will do the same thing with a longer list of words. The list will be on the screen for about 40 seconds, enough time for you to look at each word at least once.

Specific Instructions (read each when computer indicates)

Give Equal Attention

Some of the words in the list that follows are related. They are the names of _____. The rest are unrelated words. However, an equal number of the words which will be flashed are the names of _____ and unrelated words. So try to give the same amount of attention to each word so that you don't miss the unrelated words when they are flashed.

Give More Attention

Many of the words that will be flashed are the names of _____ and some will be unrelated words. So try to give more attention to the words that are the names of _____ and not as much to the unrelated words.

Give All Attention

Most of the words that will be flashed are the names of _____ and a few are unrelated words. So give all of your attention to the words that are the names of _____ and try not to be distracted by the unrelated words.

Appendix E

Listing of Computer Programs

Attention Deployment Program

```

40 LOMEM: 16800: HOME: HCOLOR = 3
50 S = PEEK (768): IF S = 32 GOTO 120
60 PRINT "BLOAD CLOCK"
120 PRINT "FIRST THE EXAMPLE WORD LIST"
130 PRINT "WILL BE DISPLAYED": PRINT
140 PRINT "STUDY ALL THE WORDS SO THAT"
150 PRINT "YOU CAN RECOGNIZE ANY ONE"
160 PRINT "WHEN IT IS FLASHED": VTAB (8)
170 PRINT "PRESS THE BUTTON AND THE"
180 PRINT "EXAMPLE WORD LIST WILL APPEAR"
190 L = 6: GOSUB 6000
200 HGR: VTAB (6)
210 FOR A = 1 TO 12
250 READ A$: PRINT A$
260 IF A/3 = INT (A/3) THEN PRINT
270 NEXT A
275 POKE -16303,0: POKE -16301,0
280 POKE 775,197: POKE 781,60: CALL 768
311 GOSUB 1500
315 POKE -16300,0: POKE -16303,0
320 VTAB (21)
330 PRINT "THE WORDS WILL BE FLASHED"
340 PRINT "IN THE MIDDLE OF THIS BOX"
350 PRINT "(PRESS THE BUTTON TO CONTINUE)"
360 POKE -16304,0
365 GOSUB 6000
367 POKE -16300,0: POKE -16303,0
370 HOME: PRINT "PRESS THE BUTTON AND THE"
380 PRINT "FLASHED EXAMPLE WORDS WILL START"
390 PRINT "(FOCUS YOUR EYES IN THE AREA WHERE"
391 PRINT "THE BOX WAS BEFORE YOU PRESS THE BUTTON)"
394 FOR A = 1 TO 10
395 VTAB (10): HTAB (13): PRINT "->"          <-"
397 GOSUB 6000
400 IF A < 9 AND A/2 <> INT (A/2) THEN L = L - 1
410 IF A > 7 OR D > 0 THEN L = 1
420 POKE -16304,0: POKE -16302,0: POKE -16300,0
430 READ A$
440 VTAB (10): HTAB (INT(20 - (LEN (A$)/2)))
450 PRINT A$: POKE -16303,0: POKE -16300,0
470 POKE 775,80: POKE 781,L: CALL 768
480 POKE -16304,0: POKE -16297,0
500 POKE 781,1: CALL 768
519 HOME
520 POKE -16300,0: POKE -16303,0
530 PRINT "SAY THE WORD OUT LOUD"
540 PRINT "IF YOU RECOGNIZED IT"
550 VTAB (5): PRINT "WHEN YOU ARE READY TO CONTINUE"
570 PRINT "PRESS THE BUTTON"
590 IF F > 0 THEN RETURN

```

```

595 GOSUB 6000
600 PRINT "THE WORD WAS      ";: PRINT A$
610 VTAB (3): PRINT "PRESS THE BUTTON TO START"
630 PRINT "THE NEXT EXAMPLE WORD"
640 NEXT A
670 HOME: PRINT "THAT WAS THE LAST EXAMPLE WORD"
680 VTAB (4): PRINT "REPEAT THE EXAMPLE? (Y OR N)"
740 POKE 49168,0: GET B$: HOME
750 IF B$ = "Y" THEN RESTORE: D = 1: GOTO 200
760 IF B$ = "N" THEN GOTO 800
770 GOTO 740
800 IF F > 1 GOTO 900
805 PRINT "EXPERIMENTER: READ GENERAL INSTRUCTIONS"
810 PRINT: PRINT "FOLLOWED BY:": PRINT: PRINT
900 FOR F = 1 TO 3
910 GOSUB 1580
972 C$(1) = "FOODS": C$(2) = "ANIMALS": C$(3) = "VEHICLES"
985 M$(1) = "EQUAL": M$(2) = "MORE": M$(3) = "ALL"
990 PRINT "GIVE ";: PRINT M$(M);: PRINT " ATTENTION"
995 PRINT : PRINT "WORDS THAT ARE THE NAMES OF ";: PRINT
    C$(N)
1000 GET B$
1010 HOME : PRINT "PRESS THE BUTTON AND THE"
1020 PRINT "LIST OF WORDS WILL BE PRESENTED"
1030 GOSUB 6000
1040 POKE -16304,0: POKE -16302,0: POKE -16298,0
1050 FOR D = 1 TO 12
1060 PRINT
1070 FOR L = 1 TO 34 STEP 11
1080 HTAB (L): READ A$: PRINT A$;
1100 IF L > #) THEN PRINT
1120 NEXT L,D
1130 POKE -16303,0: POKE -16300,0
1140 POKE 775,255: POKE 781,247: CALL 768: HOME
1200 PRINT "PRESS THE BUTTON AND THE"
1210 PRINT "FLASHED WORDS WILL START"
1220 POKE -16297,0: FOSUB 1500
1230 FOR E = 1 TO 36
1232 VTAB (10): HTAB (13): PRINT "->          <--"
1240 GOSUB 395
1250 NEXT E
1255 GOSUB 6000
1257 NEXT F
1265 HTAB (13): PRINT "INSTRUCTIONS": PRINT
1266 PRINT "EQ=";: PRINTM1,: PRINT "PR=";
1267 PRINT M2,: PRINT "EX=";: PRINT M
1270 PRINT : PRINT "EXPERIMENTER: PRESS A KEY TO ";
1271 PRINT "CONTINUE"
1275 POKE 49168,0: GET B$
1278 PRINT : PRINT "PRESS THE BUTTON TO GO ON"
1279 GOSUB 6000
1280 PRINT "RUN ML2"

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1290 END
1500 HPlot 91,60 TO 168,60 TO 168,93 TO 91,93 TO 91,60
1501 FOR Y = 60 TO 82 STEP 11
1510 FOR X = 91 TO 162 STEP 7
1520 HPlot X,Y TO (X + 7),(Y + 11)
1530 HPlot X,(Y + 11) TO (X + 8),Y
1570 NEXT X,Y: RETURN
1580 IF F = 3 THEN M = 6 - M1 - M2: N = 6 - N1 - INT(10*RND
    (0)): GOTO 1640
1590 M = INT(10*RND(Z))
1600 IF M < 1 OR M > 3 OR M = M1 GOTO 1590
1615 N = INT(10*RND(Z))
1620 IF N < 1 OR N > 3 OR N = N1 GOTO 1615
1630 IF F = 1 THEN M1 = M: N = N1
1631 IF F = 2 THEN M2 = M
1640 N = ((N - 1) * 84) + 22
1650 RESTORE
1660 FOR A = 1 TO N: READ A$: NEXT A
1690 N = ((N - 21)/84) + 1
1692 RETURN
2010 DATA LAMP,TOWEL,FIELD,CITY,SNOW,CAP,ROPE,BOX,RADIO,POST
2020 DATA BRICK,TREE,CAP,TREE,CITY,ROPE,TOWEL,POST,RADIO
2030 DATA LAMP,SNOW,BRICK
2110 DATA FEAST,SAUSAGE,SPOUT,STEAK,COOP
2115 DATA HARBOR,BREAD,PICNIC,PANTRY
2120 DATA ORCHID,GRILL,GUTTER,SPOON
2125 DATA TOASTER,BEAN,RIBBON,PAN
2130 DATA TEPEE,KITCHEN,CAFE,SNACK,HAT
2135 DATA CHEESE,APPLE,CRACKER,VARNISH
2140 DATA BACON,MEADOW,FORK,COURT
2145 DATA ORGAN,RADISH,SUIT,FALCON
2150 DATA MELON,STOVE,MEAL,WAX,MENU
2155 DATA PRUNE,COD,SPATULA,CHILI,GROCEr
2160 DATA SOUP,TURKEY,POTATO,OASIS
2175 DATA MEAL,PICNIC,BREAD,MEADOW
2180 DATA POTATO,OASIS,BACON,SNACK
2185 DATA TURKEY,SPOUTWAX,COD,GUTTER
2187 DATA SUIT,STOVE,COURT,GROCEr
2190 DATA STEAK,MENU,FORK,RADISH,SOUP
2195 DATA FALCON,PAN,HAT,CHEESE,KITCHEN
2197 DATA TEPEE,SPATULA,CHILI,APPLE,FEAST
2198 DATA RIBBON,HARBOR,GRILL,PRUNE
2215 DATA PONY,COW,TIGER,FUR,ANTLER
2220 DATA ACID,PANTHER,PAW,BARK,WOLF
2225 DATA JADE,PORCH,LAP,LION,COVER
2230 DATA CANDY,WOOL,FORT,MARSH,WIG
2235 DATA STABLE,PORK,CAVE,WING,MOOSE
2240 DATA CAT,ROAR,FOX,ZEBRA,BROOK
2245 DATA HOOK,TENT,ELK,SNOUT,TURTLE
2250 DATA MULE,GOPHER,CLAW,ZOO,PIG,CAMEL,HOOOF,RODE),SUITE
2255 DATA Tail,NOVEL,FEATHER,ALTAR,PONY,TAIL,NOVEL,CAMEL
2275 DATA WOOL,FOX,WOLF,TENT,SUITE,COW,PORK

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```

2280 DATA STABLE, TURTLE, PAW, LAP, HOOK
2285 DATA CANDY, PANTHER, FEATHER, RODEO
2290 DATA BROOK, COVER, MARSH, ROAR, ZOO
2292 DATA JADE, ANTLER, ACID, MULE, CLAW
2295 DATA ZEBRA, CAT, BARK, MOOSE, PORCH, TIGER
2305 DATA ROOT, SLED, ROCKET, MOON, TRUCK
2310 DATA QUARTZ, PILOT, MOTEL, PEDAL, ARMY
2315 DATA AUTO, BUMPER, SCARF, TRACTOR, CANOE
2320 DATA ROAD, TAXI, TOLL, TRAFFIC, JET
2325 DATA GLIDER, OAR, GROVE, MAIL, FACTORY
2330 DATA STATION, CARGO, SHIP, BUS, FERRY
2335 DATA MAST, FLAP, COCOON, FARE, TRAIN
2340 DATA WHEEL, VAN, HORN, PLATE, YACHT
2345 DATA SILK, GUITAR, HAY, GAS, CORPSE
2350 DATA BICYCLE, MOTOR, HOE, PILOT, TAXI, GUITAR, TRAFFIC, SILK
2365 DATA TOLL, FACTORY, TRAIN, JET, ROCKET
2370 DATA AUTO, OAR, BUMPER, CANOE, YACHT
2375 DATA SLED, CARGO, ROOT, BICYCLE, CANOE, YACHT
2380 DATA PEDAL, TRUCK, CORPSE, HAY, VAN
2385 DATA FERRY, MAIL, HOE, FLAP, ARMY, WHEEL
2390 DATA HORN, GAS, GROVE, MAST, QUARTZ
3110 PRINT "AN EQUAL NUMBER OF THE WORDS"
3120 PRINT "THAT WILL BE FLASHED ARE THE"
3130 PRINT "NAMES OF ";: PRINT C$;
3140 PRINT " AND UNRELATED WORDS": PRINT
3145 PRINT "SO, AS YOU ARE STUDYING THE "
3150 PRINT "LIST OF WORDS, GIVE AN EQUAL"
3160 PRINT "AMOUNT OF ATTENTION TO THE"
3170 PRINT "WORDS THAT ARE THE NAMES OF"
3180 PRINT C$;: PRINT " AND TO THE UNRELATED WORDS"
3190 PRINT : PRINT "ONCE AGAIN, GIVE THE SAME AMOUNT"
3200 PRINT "OF ATTENTION TO ALL OF THE WORDS"
3500 RETURN
4210 PRINT "MANY OF THW WORDS THAT WILL"
4220 PRINT "BE FLASHED ARE THE NAMES OF ";
4230 PRINT C$;; ^
4235 PRINT "AND SOME OF THE WORDS ARE UNRELATED"
4240 PRINT : PRINT "SO, AS YOU ARE STUDYING THE LIST"
4245 PRINT "OF WORDS THAT FOLLOWS,"
4250 PRINT "GIVE MORE ATTENTION TO WORDS"
4270 PRINT "THAT ARE THE NAMES OF ";
4280 PRINT C$;: PRINT
4290 PRINT "AND LESS TO THE UNRELATED WORDS"
4500 RETURN
5310 PRINT "MOST OF THE WORDS THAT WILL"
5320 PRINT "BE FLASHED ARE THE NAMES OF ";
5330 PRINT C$
5340 PRINT "AND A FEW ARE FROM THE UNRELATED";
5350 PRINT " WORDS": PRINT
5360 PRINT "SO AS YOU ARE STUDYING THE LIST OF"
5370 PRINT "WORDS THAT FOLLOWS, GIVE ALL OF YOUR"
5380 PRINT "ATTENTION TO THE WORDS THAT ARE THE"

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5390 PRINT "NAMES OF ";: PRINT C$;: PRINT " AND TRY NOT TO"
5410 PRINT "BE DISTRACTED BY THE UNRELATED WORDS"
5430 PRINT : PRINT "WHEN THE WORDS ARE FLASHED, HOWEVER,"
5440 PRINT "BE SURE TO SAY ALOUD ANY WORD"
5450 PRINT "THAT YOU THINK YOU RECOGNIZE": RETURN
6000 Z = PEEK (-16286): POKE -16368,0
6002 IF Z > 127 GOTO 6000
6006 Z = PEEK (-16286): POKE -16368,0
6010 IF Z < 128 GOTO 6006
6020 HOME : RETURN
```

Müller-Lyer Illusion Program

```

90 HOME
100 PRINT "THAT IS THE END OF THE FIRST PART OF THE STUDY"
110 PRINT:PRINT:PRINT "ENTER SUBJECT ID# AND PRESS 'RETURN'
    KEY"
113 INPUT S$: PRINT
114 PRINT "SUBJECT ID # = ";: PRINT S$
115 PRINT "CORRECT? (ENTER 'Y' OR 'N')"

```

```
353 Z = PEEK (-16286): If Z > 127 THEN GOSUB 410: GOTO 500
355 IF (X - X1)^2 < 2 GOTO 350
356 IF X < 112 GOTO 350
400 W = X: GOSUB 900
410 HCOLOR = 0: W = X1
411 IF X < 112 THEN HPLOT 112,90 TO 255,90: GOTO 413
412 HPLOT X, 90 TO W,90
413 GOSUB 910
414 IF Z > 127 THEN RETURN
415 HCOLOR = 3
416 IF X1 < 113 THEN GOSUB 210
417 HPLOT 111,90 TO X,90
419 Z = PEEK (-16286): IF Z > 127 GOTO 500
420 X1 = X: GOTO 350
500 POKE -16368,0
505 HCOLOR = 0: HPLOT 112,90 TO 255,90
506 FOR F = -1 TO 1
507 W = X + F
508 IF W > 111 THEN GOSUB 910
509 NEXT F
510 IF (W - X1)^2 > 2 THEN W = X1
511 A(B) = W
520 FOR C = 1 TO 3
530 FOR D = 1 TO 10: S = PEEK (-16336): Next D
540 NEXT C,B
590 POKE -16302,0
600 FOR B = 1 TO 30
610 PRINT A(B);: PRINT " ";
620 NEXT B
690 PRINT "CHAIN TOUT"
700 D$ = CHR$(4)
710 PRINT D$;"APPEND OUT"
720 PRINT D$;"WRITE OUT"
725 PRINT SUBJECT
730 FOR B = 1 TO 30
732 X = 255 - A(B)
733 PRINT X
734 NEXT B
740 PRINT D$;"CLOSE OUT"
745 HOME : TEXT
746 POKE -16301,0
750 PRINT "END PART II"
899 END
900 HPLOT 112,90 TO W,90
910 HPLOT (W + 15),75 TO W,90 TO (W + 15),105
930 RETURN
```