CREATIVITY STIMULATION TECHNIQUES

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A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

in the Faculty
of
COMMERCE AND BUSINESS ADMINISTRATION

We accept this thesis as conforming to the
required standard

THE UNIVERSITY OF BRITISH COLUMBIA

June, 1975
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ABSTRACT

The purpose of this thesis is to compare the relative effectiveness of several techniques for encouraging creative problem solving by individuals working alone. To this end the concept 'Creativity Stimulation Technique' was coined. Chapter One contains an exploration of the conceptual and theoretical implications of the Creativity Stimulation Technique or C.S.T. This chapter provides a conceptual framework for the chapters to follow. Chapter Two brings together a diverse and hopefully comprehensive collection of published empirical studies which have tested aspects of the effectiveness of various techniques. Chapter Three describes the experimental methodology which was used to provide a comparative test of several different C.S.T.'s. Chapter Four describes the results of the experiment. Finally, Chapter Five discusses the results, develops conclusions and suggests implications of the research for future studies.
ACKNOWLEDGEMENTS

I received assistance considerably above and beyond the call of duty from two members of my committee. Firstly, I want to thank Dr. Ron Taylor for his excellent advice upon research methodology as well as for the support and encouragement which he continuously provided. I remember one particular Saturday noon when I arrived at his office with my entire manuscript in hand, extremely frustrated by the pressures of time. By Monday noon, Ron had read and commented upon the entire thesis.

The other individual I must single out is Dr. Ken MacCrimmon. Ken was the spiritual father of this thesis. In fact, I do not ever remember sitting in on a discussion with Ken without feeling the wiser for it. Ken provided the general theoretical and conceptual development of the thesis and as such, it would have been an impossibility but for him.

Furthermore, I would like to thank a number of other people who made their mark upon this work, namely, Dr. Vance Mitchell, Dr. Rick Pollay, Dr. Peter Seudfeld and Dr. Karl Sarndal.

Finally, I would like to thank Betty Secretan for the frustrating hours she spent typing and retyping the thesis.
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Chapter 1. Resolving Conceptual and Theoretical Issues

Designing an experiment to test the relative effectiveness of different creativity stimulation techniques necessitated resolving several neglected conceptual and theoretical issues. Before choosing which techniques to research it is expedient to determine what constitutes a creativity stimulation technique. Similarly, one should determine what constitutes the core ideas in a technique before he attempts to operationalize it. Moreover if one does not know with what problems the techniques are applicable, he will be hard-pressed to choose problems for testing. Without a conception of what constitutes creativity it is unwise to set up a rating scale for evaluating answers. One's choice of subjects is dependent upon one's theory of the psychology of the technique's functioning. Finally, one should design procedural instructions for the experiment based upon some conception of the creative process.

1.1 A Definition of a Creativity Stimulation Technique

A creativity stimulation technique (C.S.T.) is a set of instructional heuristics suitable for creative problem-solving. Firstly, to call these techniques "instructional heuristics" is not to imply that a great deal of skill won't be required to use them effectively. Training and practice in the use of these techniques is often necessary. Secondly, to state that C.S.T.'s are "suitable for creative problem-solving" is to limit the definition of techniques to those used to generate solutions to problems. Techniques used to generate artistic expressiveness would be considered beyond the definition. Having defined C.S.T.'s allows one to focus attention upon a reasonable number of researchable techniques.
1.2 A Description of Different Creativity Stimulation Techniques

Whole books (e.g. Gordon, '61 and Osborn, '57) have been written to describe the nature and usage of single C.S.T. This section contains only a capsulized description of the central characteristics of ten different C.S.T.'s. Such a condensed review is necessary to prepare the way for choosing which techniques have promise for research and furthermore for suggesting means for operationalizing the selected techniques.

1.2.1 Analogies

The use of analogies as a means of fostering the development of creative ideas was recommended as part of a total program of creative techniques entitled synectics (Gordon, 1961). In addition to advocating the use of analogies, Gordon suggests the use of the techniques of deferred judgement and record keeping as well as specific group compositions and interaction patterns. However, analogies including those of a biological genre (bionics), constitute the core of synectics.

Gordon suggests that analogies be used both to make the familiar strange and the strange familiar. By so doing one may obtain an entirely new perspective upon a problem. Furthermore, Gordon suggests that skill is needed in the use of four different types of analogies:

1. Direct analogies. These are direct comparisons between two partially similar objects or processes.

2. Personal analogies which involve taking the roles of persons or objects in a problem.

3. Fantasy analogies requiring that one imagine ideal solutions to the problem no matter how far-fetched they may seem, and then adjust these solutions to make them more feasible.
4. Symbolic analogies which require the subject to model the problem situation using whatever symbols appear appropriate to represent the objects and relations in the situation.

Gordon infers that one should free-associate with ideas and images until one happens upon appropriate analogies. From that point on one develops the problem-situation parallel to the development of the analogy.

1.2.2 Brainstorming

Brainstorming was first outlined in Alex Osborn's 1953 book, *Applied Imagination*. This technique involves simultaneously doing four things. First of all, one must break decision-making into two stages -- the first known as ideation (or idea generation) and the second as evaluation (or judgement). In the first stage the subject is required to be non-critical of his ideas. In other words, he is to defer judgement until evaluation time. Secondly, the person is instructed to give his imagination free rein. He is encouraged to write down whatever ideas come to mind. Thirdly, the subject is encouraged to go for quantity. The more ideas the better. The fourth and final aspect of brainstorming involves the use of interacting groups. The interacting group, however, has been found in almost all experiments to inhibit the generation of creative ideas and is no longer considered by many to be an essential element of brainstorming.

1.2.3 Creative Process Heuristics

Creative process heuristics are techniques which provide the problem-solver with a conception of the creative problem-solving process. For example, the subject may be requested to proceed through a sequence
of stages while solving the problem. Johnson ('72) suggests that creative problem-solving has three stages:

1. preparation and problem definition
2. production or generation of alternative possible answers
3. judgement or decision between alternative possibilities

Evidence exists to suggest that the first stage should really be two distinct steps or sub-stages: firstly, consideration of what is known of the problem - the initial state, and secondly, consideration of the criteria for evaluating the solution -- the final state (Brilhart and Jochem '64). Other stages formats include such steps as:

1. preparation
2. incubation
3. insight
4. verification

(Haefele, '62)

Polya ('45) suggests a four stage problem-solving format each stage being elaborated by several idea spurring questions. The four stages are entitled: understanding the problem
devising a plan
carrying out the plan
looking back

An entirely different conception of the creative process is utilized by Reitman ('64). He sees creation as the successive generation of constraints - each subsequent constraint narrowing the number of possible alternatives or allowable variations remaining. It is crucial that the constraints be laid in the correct order until constraint by
constraint one builds, by exclusion, the creative idea desired. Alternatively, one might conceive the creative process as elaborating by degrees upon key or core ideas - building outward in effect.

Yet another conception of creative problem-solving involves the subject in a repetitive cycling through the problem-solving process and with each cycle making incremental improvements to the solution he provides. Initially the subject has a vague conception of the problem and engages himself in a very general search for information. By synthesizing his newly attained information with that previously available he is able to gain a new problem perspective and a refined definition of the problem. Variations of this technique have been referred to as solving the problem twice (Maier and Hoffman, '60) and disjointed incrementalism (Braybrooke and Lindbloom '60).

By actively utilizing one of these problem-solving conceptions the subject should be able to heighten his creative skills.

1.2.4. Final State Elaboration

A final state elaboration technique orients the subject towards the nature of the problem solution. Three different approaches to final state elaboration are available. Firstly, the subject might be provided with an abstract description of creative problem solutions. For instance, a creative idea may be described as an idea which is both original and potentially valuable. Secondly, the subject may be asked to produce an abstract description of a creative solution to the type of problem under consideration. For example, one might be asked to characterize potential solutions to a problem in terms of their key dimensions, (i.e. dimensionalize the solution space). Thirdly and finally, it might be suggested to the problem-solver that he examine constructively other existing solutions
to his problem or to similar problems before he attempts to produce his own solutions.

1.2.5. **Forward-Backward Problem-Solving**

Polya ('45) described working backwards as "starting from what is required and assuming what is sought is already found" (p. 227). With forward problem-solving one starts with a description of what is known and progressing from there towards what is yet unknown and desired to be found. Forward-backwards problem-solving implies that the subject should alternate between developing the possible implications of the known (forward problem-solving) and generating reasonable suboptimal solutions alternatives. This approach metaphorically resembles digging a tunnel from two pre-specified points on either side of a mountain with the difference that the tunnel ends would magnetically attract each other as the forward drilling team and the backward drilling team began to come into close proximity.

1.2.6. **Free Association**

The free association technique contains the injunction that one muse in a free-flowing and easy-going manner over a topic or a problem. One might start with a poorly specified problem and meditate upon what is known or unknown regarding the problem solution. By using a stream of consciousness style of thinking one often deviates substantially from the original topic. To avoid extended mental meanderings and musings one might be advised to fix the problem firmly in mind at the beginning and to periodically revert to it during free association. Then again one might use the problem concepts almost like mental mantras and meditate upon them.
1.2.7. **Incubation**

To incubate an idea, in actuality, means to be diverted in the middle of the problem-solving process. One may reach an impasse with a problem and instead of continuing to work himself into a state of frustration he will be advised to leave the problem for awhile before going back to it. In the interim he may work upon something else. Theoretically his subconscious will continue to work upon the task while he is occupied by the second problem.

1.2.8. **Initial State Elaboration**

There are two basically different strategies for initial state elaboration. Firstly, those techniques which stimulate the drawing of new and relevant inferences from the information already available in the initial problem statement (internal techniques). And secondly, those techniques which encourage subjects to compare the initial information with or by means of external ideas in an attempt to generate new relevant inferences, (external techniques).

The internal techniques include attribute listing, forced comparisons and forced completions. Attribute listing requires firstly, the exhaustive compilation of attributes of the problem situation - including the artifacts and processes described therein. New or original ideas may result from finding novel combinations or attributes. The forced comparison technique requires the problem-solver to bring essential pieces of information together to look at their common implications. When wishing to synthesize seemingly desperate evidence into an as yet non-existent typology, a problem-solver might scatter his pieces of data upon a flat surface and then pick up the ideas at first two at a time and then in larger numbers as natural groupings.
began to appear. With forced completion the problem-solver assumes
the existence of something yet to be found. If he had classified seven
types of widgets he might then ask himself what the eighth type would
look like.

The external techniques include checklists and relational algorithms.
A checklist is a series of suggested ideas from which to view or alter
aspects of the problem situation. The subject usually is advised to use
the items on the list in sequence. When one item has been mined out then
the subject moves to the next one. The list itself serves as a mnemonic device
insuring that the subject is comprehensive in his approach. (Osborne '53)
suggested the following checklist items: put to other uses? adapt? modify?
whom? The relational algorithm (Crovitz, '70) suggests that the subject
take two main elements in the problem statement and relate them by means
of a set of prepositions. Crovitz provides a complete set of prepositions
to aid in this task.

The applications of these different initial state elaboration tech­
niques will either allow an improved restatement of the problem or a
viable solution to it.

1.2.9. Modelling

Modelling involves replicating the essential elements of a problem
situation. If one is striving to replicate dynamic elements in the
situation, the resulting model would be a simulator. Models may have
two or more dimensions. Then again the model user may strive for an
exact or a symbolic representation of the problem situation. Moreover,
models vary in their abstractness and in their remoteness from realism.

1.2.10 Morphology

Morphology is a relatively complex technique originally suggested for the development of new inventions. F. Zwicky formulated and popularized the technique in 1948. Zwicky's description of the technique involved the following four steps:

1. The problem to be solved, or the functional capability to be achieved must be stated with great precision;

2. The characteristic parameters must be identified (this is to a considerable degree an automatic consequence of the precise statement at (1). Completeness, however, is the problem and only the analyst's capabilities can ensure it);

3. Each characteristic parameter must be divided into distinguishable cases or states (say $p_n$, $p^2_n$, $p^3_n$...); or more frequently a continuum of values must be meaningfully clarified into ranges or regimes, e.g. sub- and super-sonic speeds may be seen as clear cases whereas supersonic and hypersonic regimes are not clearly divisible;

4. Some "universal" method of analyzing the performance and feasibility of the various combinations is required, although Zurcky concedes that this is no easy task. Indeed it is seldom practical, and a variety of extensions to his original formulation have attempted to grapple with the data deluge which normally arises (Wills, 1972, p. 135).

Alternatively the problem-solver might dimensionalize either the initial state or the solution space as first step in using morphology. Then he would provide exhaustive sets of values for each dimension.
Thirdly, the problem-solver might arbitrarily choose one or more values from each dimension and juxtapose them in what might be termed multi-valued concepts. Finally, he would utilize these concepts as an ejection point for creative thinking (see page 149 for clarification).

1.3 A Concept of Creativity

In order to develop rating scales to evaluate subject responses it is necessary to develop a concept of creativity.

Creativity is a two dimensional concept. For something to be creative it has to be both original and potentially practical. In turn an original idea is one which would occur infrequently within a population. Highly original responses may be produced on demand by schizophrenics; however, the overwhelming majority of such ideas are unlikely to be practically significant. On the other hand, potentially practical ideas for many organizational problems can be proferred by the average businessman with common place regularity. Many of these ideas would hardly be called original though. As illustrated below, creative ideas are both original and potentially practical*.

Figure 1.1 Dimensions of Creative ideas

<table>
<thead>
<tr>
<th>Potentially practical (feasible)</th>
<th>Original</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potentially practical (feasible)</td>
<td>No</td>
<td>Insignificant ideas</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>Mundane Ideas</td>
</tr>
</tbody>
</table>

* It is interesting to note that the first U.S. patent law in 1790 defined an invention as something which was both novel and useful. Much the same definition of inventions prevails today. (Hummerstone, '73).
A number of empirical studies have demonstrated that subjects can produce "original" ideas on demand (e.g. Maltzman, Bogartz, and Breger, '58). Other studies demonstrate that subjects can be successfully requested to produce practical solutions to problems by merely asking them to do so. (e.g. Manske and Davis, '68). However, it is doubtful that creative ideas can be produced as a result of simple requests (Manks and Davis '68)*. In fact Johnson ('72) found a negative correlation of -.80 between the ratings of originality and practicality, using the Manske and Davis data which suggests a trade-off in a person's ability to be either original or practical on demand. The following diagram illustrates this trade-off.

Figure 1-2 Trade-off between originality and feasibility

* See Chapter 2, page 50.
The above diagram asserts that ideas have to be both minimally original and minimally practical to be creative. The production possibilities curve illustrates the trade-off available to an individual in whether or not he might choose to be original or practical. The curve illustrates that even though a particular person has the skill to either be practical or original on request it is not as easy for him to be creative. The function of a creativity stimulation technique is to bend the individual's production possibility curve to the right and further into the zone of creativity. A mere request is usually not adequate for stimulating creativity. A creativity stimulation technique has to provide for something more.

1.4 What Problems Require C.S.T. Assistance?

In choosing problem tasks for the experiment it was important to ask firstly what constituted a creative problem and secondly what different types of creative problem tasks there might be. If one is to be able to generalize upon the effectiveness of a C.S.T. he probably should have some appreciation of the population of situations to which he might generalize. Hence, it became useful to attempt to construct a taxonomy of problem types.

Creative Problems are problems which permit creative answers or answers which are both original and potentially feasible.

Problems allowing for creativity are typically problems which have more than one possible answer. In fact, these problems usually allow a multitude of acceptable answers of varying qualitative degrees. The problems chosen for empirical research vary from the relatively simple to the moderately complex. A subject may be asked how many uses he can think of for a broom or a coathanger or he may be asked to think of different
programs for encouraging Europeans to vacation in North America or then again, of programs to reduce the amount of mutilation of magazines and books in a library. More difficult problems still might ask such questions as "how can a person of average ability achieve fame and immortality even though he does not possess any particular talents?" (Zagona et al. 1966, p. 117).

In classifying problems, researchers normally refer to types of problems by the tests from which they were taken (e.g. the Plot Titles Test which involves naming short stories). Another distinction which is commonly chosen is between real and unreal or fanciful problems (e.g. Dunnette et al. 1963). Even the concept of a 'hot' problem (problem of current interest) has been introduced into the literature (Dillon et al., 1972).

The theoretical writers are more vague still upon the question of problem types. They normally imply that the range of problems to which their techniques are applicable are as large as the range of problems which mankind must face.

One attempt to develop a taxonomy of creative problems divided the problems into three categories: explanation, prediction and invention (Zagona et al. 1966).

"The goal of 'explanation' is to understand why a certain event has occurred. The products of people like Galileo, Einstein, and Newton would fall into this category. For 'prediction' the goal is to understand future consequences, given certain conditions. The goal of 'invention' is to create a set of new conditions which will result in a specified event" (p. 113).
Zagona et al. classify many of the commonly used research problems into this framework.

The taxonomy of problem tasks developed herein is based upon four different dimensions of the solution to the task. The first dimension (explanation - design - prediction) is very similar to Zagona's, the concept 'design' replacing 'invention'. 'Design' is further dimensionalized into process and structural designs and again into design adaptations and design inventions as illustrated below:

Figure 1.3 Taxonomy of Creative Design Problems

<table>
<thead>
<tr>
<th>Creative Design</th>
<th>Adaptation</th>
<th>Invention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structure</td>
<td>1. Structural adaptation</td>
<td>2. Structural invention</td>
</tr>
</tbody>
</table>

A structural design constitutes a new artifact, object or structure and is static whereas a process design constitutes a new program or process and contains within it a temporal dimension. Those designs which are basically new variations of other existing designs are called adaptations whereas those designs involving basically different combinations of new ideas are called inventions.

The fourth and final dimension included in this taxonomy includes the concept of elaboration. An idea in rough is usually only a starting point in the creative process.

The schematic on the next page illustrates the completed taxonomy of problem types.
Figure 1.4 Taxonomy of Creative Problem Tasks

<table>
<thead>
<tr>
<th>Explanation</th>
<th>Unelaborated</th>
<th>Elaborated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural Adaptation</td>
<td>An idea for structural</td>
<td>A plan for structural</td>
</tr>
<tr>
<td></td>
<td>idea*</td>
<td>adaptation</td>
</tr>
<tr>
<td></td>
<td>An idea for a basically</td>
<td>A plan for a basically</td>
</tr>
<tr>
<td></td>
<td>new structure</td>
<td>new structure</td>
</tr>
<tr>
<td></td>
<td>An idea for adapting a</td>
<td>A plan for adapting a</td>
</tr>
<tr>
<td></td>
<td>process</td>
<td>process</td>
</tr>
<tr>
<td></td>
<td>An idea for a basically</td>
<td>A plan for a basically</td>
</tr>
<tr>
<td></td>
<td>new process</td>
<td>new process</td>
</tr>
<tr>
<td>Prediction</td>
<td>An idea of what is to</td>
<td>An analysis of what is to</td>
</tr>
<tr>
<td></td>
<td>come</td>
<td>come</td>
</tr>
</tbody>
</table>

* the cells contain descriptions of the solutions to the various creative tasks.
1.5 How Do the C.S.T.'s Work?

One must have some conception of how the creativity stimulation techniques work first of all to choose who would make appropriate subjects and second of all to know how to instruct the subjects in their useage.

Don Koberg and Jim Bagnall's recent book The Universal Traveller (1974) states that the five basic "learnable" characteristics of creativity are:

1. freedom from pride
2. belief in one's own ability to succeed
3. constructive discontent
4. wholeness
5. the ability to escape from habit (p.10)

They then present their readers with a plethora of techniques to teach the above "keys" to creativity.

James D. Adams' 1974 book, Conceptual Blockbusters describes creativity stimulation techniques as means for overcoming what he calls conceptual blocks' hence the name conceptual block-busters. "Conceptual blocks are mental walls which block the problem-solver from correctly perceiving a problem or conceiving its solution." (p.10). He describes five genres of conceptual blocks:

1. perceptual blocks
2. cultural and environmental blocks
3. emotional blocks
4. intellectual and expressive blocks
5. conscious blocks

He then details the mixed bag of techniques and attitudinal skills necessary to overcome the conceptual blocks:
- a questioning attitude
- fluency and flexibility in thinking
- morphology
- checklists
- the creative process heuristics of Polya (1945)
- visual thinking
- other sensory languages
- brainstorming
- synectics
- meditation

One alternative to the above conceptions is to think of C.S.T.'s as basically accomplishing a change in one's perceptual set. But it was noted perviously (p. 11) that simple requests to be creative are usually inadequate to stimulate creative performance therefore C.S.T.'s probably accomplish more than an alteration in one's perceptual set.

At the other extreme, one would see one's potential to be creative in terms of creative abilities which constitute a part of the structure of human intelligence (e.g. Guilford and Hoepfner, '71). Opinions have been mixed as to whether creative abilities are distinct from general intelligence. More recently however, split brain studies have physically located the source of creative talent within the right hemisphere of the brain and the source of rational thinking in the left. (Ornstein, '72, Gazzańiga, '67) As a result it is more probable than ever now that the conception of distinct 'creative abilities' will be generally accepted. Even if one acknowledges however, that one's potential to be creative is at least partially a function of these abilities one is still unable to explain
the results of creativity stimulation research in terms of abilities. Abilities, by generally accepted understanding, can be altered only slowly degree-by-degree, whereas creativity stimulation research has demonstrated the capacity to alter creative abilities radically and in short order.

In conclusion then, creativity stimulation techniques must do more than alter psychological set but do less than change basic creative abilities. The concept of 'creative skill' lies somewhere in between that of 'creative set' and that of 'creative ability' in that a creative skill is more malleable than a creative ability but less than a creative set.

A careful review of the C.S.T. literature suggested that a person adopts certain cognitive skills when he effectively uses creativity stimulation techniques. The effective employment of these attitudes constitutes creative skills. In fact the mere maintenance of certain of these attitudes may be looked upon as a creative skill. The presence of similar ideas in the creative personality literature serves to validate the specific creative skills presented here. The present conception of creative skills would include the following:

1. The skill of not only tolerating but also utilizing uncertainty especially that type of uncertainty associated with ambiguity or complexity. In effect, delaying psychological closure.
   - this skill is fundamental to more than one creativity stimulation technique. For example both synectics and brainstorming claim a heavy reliance upon deferred judgement.
   - in personality research, a preference for complexity has been observed as a basic characteristic of creative individuals (Dellas and Gaier, 1970).
2. The skill of using a constructive as opposed to a critical attitude.

Taking a positive approach to problem-solving. Utilizing an attitude which views problems as opportunities.

- Hyman (1961) and others* have experimentally demonstrated the effectiveness of a constructive set.
- Koberg and Bagnall (1974) list 'constructive discontent' as one of the essential attitudes of a creative problem-solver.
- in the personality research, confidence and self-esteem have been linked with the creative personality (Dellas and Gaier, (1970).

3. The skill of adjusting one's frame of reference or perception of the problem situation by (a) continuously redefining the problem, (b) transposing ideas and solutions from other contexts or (c) oscillating between levels of abstraction in thinking about the problem.

- analogies are one means used to ensure an alteration of one's frame of reference (Gordon, 1961).
- the personality literature has isolated cognitive flexibility as an important characteristic of the creative thinker (Guilford and Hoepfner, 1971).

4. The skill of visualizing the problem-solving process.

- creative process heuristics stress the value of this skill.
- many creative people have demonstrated a conception of the creative process as is evidenced by anthologies of writings by famous creative people (Ghiselin 1952).

* See pages 48 and 54.
5. The skill of being able to visualize the problem-situation.
   - initial state elaboration, modelling, and final state elaboration all encourage the visualization of the problem situation to varying degrees.

   - creative problem solving has been successfully related to ambiguous symbols tasks (Jacobsen & Asher, 1963).
   - Koberg and Bagnall (1974) highlight perceptual blocks as a key impediment to creativity.

7. The skill of working hard in an easy manner. Freedom from high levels of anxiety while working.
   - Osborne (1953) and Gordon (1961) amongst others stress the importance of making creative problem-solving an enjoyable non-threatening experience.

8. The skill of suspending judgement. Of not being overly critical of one's new and fragile ideas before they have undergone any substantial development.
   - this is a common requirement of creativity stimulation techniques.

9. The skill of producing large numbers of ideas.
   - an integral element in brainstorming and morphology.
   - entitled 'fluency' by structure-of-intellect researchers, and linked with creativity (Guilford and Hoepfner, 1971).

10. The skill of abstraction. Being able to see essential elements in a problem-situation.
    - the most important step in modelling.
Questions remain regarding the completeness of the above set of mental skills; of their independence of each other; and of the uni-dimensional nature of individual skills. Moreover, the relative effectiveness of these skills has yet to be demonstrated.

There are a number of advantages to be derived from such a list of creative skills. Firstly, it should provide direction for future research. Secondly, the theory should be useful in explaining the underlying psychology of creative thinking and perhaps will provide new insights into the creative process itself. Thirdly, the theory should provide a basis for evaluating and improving existing creativity technology. Fourthly, and finally, entirely new techniques may be the outcome of such an examination of the ways in which techniques function. Others may conceive alternative means for operationalizing the set of mental skills more effectively and efficiently than before.

1.6 What is the Creative Process?

In developing procedural instructions for subjects to follow during the experiment one may have to refer to some conception of the creative process. Moreover, it is entirely possible that one might not see the C.S.T.'s as equally appropriate for all stages of the creative process.

A useful conception of the creative process is the following:

stage 1: a) preparation and analysis  
        b) problem definition

stage 2: alternative generation

stage 3: evaluation or judgement

stage 4: elaboration

The most generally accepted conceptions of creativity are in terms of
the generation of alternative solutions to problems. Moreover, it is accepted that evaluation or judgement was a function of other than creative abilities. But what of stage 1, preparation and definition, and stage 4, elaboration? Are not these stages in the creative process accessible to creativity stimulation?

It is apparent that 'plot titles' problems have a basic similarity to problem definition. It has been demonstrated that C.S.T.'s can be used effectively on 'plot titles' problems thereby suggesting that stage 1 is conducive to creativity stimulation. Furthermore, such techniques as initial state elaboration and modelling have an obvious use in clarifying the problem information for improved definition. Moreover, sensitivity to problems, analysis, synthesis and redefinition abilities are listed as components of "abilities in creative thinking and planning" by the factor analytic school of creativity (Guilford and Hoepfner, 1971, p. 125). Therefore considerable thought might be given to applying the techniques to stage 1 of the creative problem-solving process as well as to stage 2.

As to elaboration; very little research has been conducted which demonstrates that C.S.T.'s can be useful tools for elaboration. Some of the C.S.T.'s such as: analogy, creative process heuristics and modelling seem definitely suited to elaboration. What is more, the factor analytic school of creativity classifies elaboration as a component part of the "abilities in creating thinking and planning" (Guilford and Hoepfner, 1971). Therefore, researchers might also pay attention to the value of creativity stimulation techniques as tools for elaboration.
In addition, free association and incubation have the potential to improve performance on all the problem-solving stages.

In summary, altogether too much attention has been directed towards alternative generation and in particular towards such creative abilities as fluency, flexibility, and originality to the exclusion of the other stages in the creative process. It is very probable indeed that creativity stimulation techniques will be useful for preparation - definition and elaboration as well as for alternative generation.

1.7 Summary and Conclusion

The elaboration of theories and concepts above constitutes the conceptual framework which was necessary, firstly, to design the thesis experiment. Secondly, the conceptual framework was needed to interpret the external validity (Campbell and Stanley, 1966) of the experimental results. Thirdly, such a framework was necessary not only to interpret previous findings of other experimental research but also to relate these findings to the results of the experiment contained herein.

More generally still, the concept, creativity stimulation technique is not as yet a generally accepted concept in the literature on creativity, and as a result it has proven necessary to explore the theoretical ramifications of such a concept. This chapter, in conjunction with the one to follow, yields the following conclusions.

1. The C.S.T. concept can be effectively used to integrate a now disparate literature.

2. The C.S.T. concept can be used to generate new ideas for encouraging and researching creativity.

As a result it is probably fair to conclude that the C.S.T. concept is viable and merits general usage in the literature.
Chapter 2. Creativity Stimulation Techniques - The Empirical Research

The following review is intended to be a guide for researchers to current scientific knowledge about the effectiveness of various creativity stimulation techniques. To gain an understanding of empirical studies on such techniques it is important that a reviewer provide information on three different aspects of each technique:

1. the manner in which the techniques have been successfully operationalized.
2. the nature of the problems upon which the techniques have been successfully worked.
3. the measures of success which have been used to gauge the performance capabilities of the techniques.

Other matters of potential interest include the degree of training required before subjects can effectively use the technique, the nature of the subjects, the time given to apply the technique, and the nature of the comparison group. Often this information is only partially available in the published studies.

It is important to know how a technique has been operationalized so as to ascertain how one might go about employing the technique. For one to say "use free association" on a specific problem is really not to provide much guidance in solving that problem. If on the other hand, one is told to take the key 'elements' in a problem situation and to list on paper all the associates one can make with those 'elements' as the first step in problem-solving then one has a much better idea of how to approach the problem. Secondly, it is important to know which problems a technique has been successfully employed
upon, as it is too much, at our given state of knowledge, to expect a technique to be universally useful. Thirdly, many researchers confuse originality or fluency of response with creativity and the evidence to date is sufficiently varied to make it unlikely that a technique will significantly outperform other techniques or instructions on all measures of performance.

The studies which are reviewed here (57 in all) span the years 1938 through 1974 and are fairly evenly dispersed from 1959 onward. Key figures in this literature include: T. J. Bouchard, D. M. Johnson, J. Maltzman, A Meadows and S. J. Parnes. Certain of the techniques have received more attention than others, thus there is an imbalance in attention given the techniques. For example 23 studies were found relating to brainstorming whereas only 2 studies could be found upon each of the following: analogy, creative process heuristics, forward-backward problem-solving, incubation and morphology. Three studies were found upon modelling. The other techniques which are represented in this review are final state elaboration (9 studies), free association (10 studies) and initial state elaboration (8 studies).*

This paper will review the techniques in order of amount of evidence available. Within each set of technique studies the relevant articles will be described chronologically. The evidence upon each technique will be separately summarized at the end of each technique section.

2.1 **Brainstorming**

Twenty-three studies on brainstorming are discussed below. Unfortunately though, only thirteen of the studies have a bearing upon the

*n.b., nine studies relate to more than one technique.*
relative effectiveness of brainstorming. The other eight studies all deal with the question: under which conditions is brainstorming most effective? In particular the comparative effectiveness of real (interacting) versus nominal group constitutes the central issue in these latter studies. As this review is primarily intended to discuss the relative effectiveness of various creativity stimulation techniques, the studies contrasting real and nominal groups will receive only brief mention.

In 1956 Chorness discussed the results of two studies on brainstorming at a meeting on creative problem-solving in Chicago. The article was subsequently published in the Journal of Communications in 1958. This informal, incomplete presentation which received little subsequent recognition is the earliest piece of published research which could be found upon brainstorming. In the first experiment reported therein, treatment subjects were "taught in a regular academic course in leadership utilizing the Osborn technique.* The controls received instructions in the normal way. Both groups were pre-tested on tests designed by Guildford to measure creative ability. At the termination of the experimental session both groups were tested again...." (p.21). The gain shown by brainstormers was not significantly greater than that shown by control subjects. A second course (the second experiment) was offered in creativity in which "the Osborn technique was incorporated as a stimulant when required. This time the results were in favor of the experimental group" (p.22).

The second empirical study on brainstorming was concerned with the real group versus the nominal group effectiveness question. Taylor, Berry and Block (1958) found results decisively in favor of nominal over

*n.b. the Osborn technique primarily involves instructions in brainstorming.
interacting groups and for interacting groups over individuals. Performance was measured in terms of the number of ideas and the number of unique ideas. Responses to the tourist and teach problems were also measured in terms of feasibility, effectiveness and generality. The nominal groups outperformed the real groups on the sum of those three ratings at a .0001 level of significance and generality ratings were used to evaluate the thumbs problem. The sum of those three measures were used to show a difference in performance again favoring nominal over real groups at the .0001 level of significance.

There next followed a series of studies instigated primarily by A. Meadow and S. J. Parnes. In their first article, Meadow and Parnes (1959), found that subjects who had participated in a one semester course in creative problem solving emphasizing brainstorming were superior on five out of seven measures of creative ability to a group of matched control subjects who had not taken the course.

In a second study (Meadow, Parnes and Reese, 1959) the authors again chose as subjects college students who were enrolled in two sections of a course on creative problem-solving (N=32). The subjects this time were randomly assigned to one of two conditions.

**Condition 1:** (Brain-storming) Brainstorm to your fullest ability; forget about quality entirely. We are going to count only quantity on this test.... Quality is of no concern at all.

**Condition 2:** (Non-brain-storming) Forget all about brainstorming. Strive completely for quality. We want to see how many good ideas you can produce in a certain amount of time. You are going to be penalized for any bad ideas. Any ideas rated as poor will be subtracted from your score.
The problems chosen for this study were "other uses problems": other uses for a broom and for a coathanger. About twice as many "good" ideas were produced under the brainstorming treatment. (p.<.001).

Their third study (Parnes and Meadow, 1959) utilized "untrained students who had never received previous instruction in the method" (p.171). The hanger and broom uses problems were again employed but this time with a new scoring method. The authors derived a "creativity quality" score which was based both upon the "uniqueness" of the idea and upon its "socially useful value" (p. 172). Moreover the control instructions were much more neutral in this experiment:

You are to list all the good ideas you can think up. Your score will be the total number of good ideas. Don't put down any idea unless you feel it is a good one.

Brainstorming instructions resulted in nearly twice as many "good" solutions (p.<.001). Furthermore the number of "good" ideas produced by untrained brainstormers were compared with those of brainstormers who had been trained in a university course. Course training again doubled the number of "good" ideas (p.<.01).

The fourth study (Parnes and Meadow, 1960) "was designed to evaluate the persistence of the effects produced by the Creative Problem-Solving Course" (p.356). This time performance was measured on six ability tests which included: "the Guilford Apparatus (Quality), Unusual Uses (Quality), and Plot Titles (Quantity and Quality) tests, and the item, "List all possible uses for a wire coathanger", from the A C Test of Creative Ability (Quantity and Quality)" (p. 359). Interrater reliabilities ranged from a low of .74 to a high of .94. Experimental subjects had "completed the course from eight months to four years before the
experiment. Control subjects were students registered, but uninstructed, in the Creative Problem-Solving course. No subject had ever before taken the creative thinking tests" (p. 360). The trained subjects outperformed the two sets of untrained subjects on all six measures but in varying degrees (from nonsignificant to .001 sig.).

Cohen, Whitmyre and Funk (1960) conducted a study on the group versus individual question. Their results favored trained cohesive real groups over trained nominal groups and trained nominals over trained non-cohesive real groups. A cohesive real group was constituted of two people who preferred to work together. Performance was measured both in terms of the total number of ideas and of the number of unique ideas.

The last of the Meadow and Parnes studies mentioned here was conducted by Parnes in 1961 and measured the quality of idea production according to the time length of the brainstorming session. The last two and one-half minutes were found more productive of "good" ideas for hanger uses than was the first two and one-half minutes, the effect persisted. Good ideas tended to come late in the brainstorming period.

Another study in 1961 (Weisskopf - Jackson and Eliseo) contrasted brainstorming instructional effects with logical problem-solving instructions, which were summarized as follows:

1. Think clearly and logically. Try to see all aspects of the problem. 2. We want good practical ideas. 3. We want a number of ideas from which to later judge the better ones; however the emphasis is on quality not on quantity. 4. Combination and improvement of ideas is desired.

The problems required the invention of brand names for three kinds of products, namely; a cigar, a deodorant, and an automobile. Average inter-rater reliability was .72 for quality of names. The results showed that
brainstorming instructions produced dramatically more ideas but not more of the high quality ideas. The judges, however, were 150 Purdue male undergraduate students. The authors conclude "that such conventional names as 'Sportsman', 'Esquire' and 'Century' were among the three most highly-rated brand names, suggest(ing) that the imaginative ideas of brainstormers were wasted on the conservative taste of the judges. Perhaps judges and consumers with a greater preference for unusual brand names could throw a more favorable light on brainstorming". (p. 49)

Dunnette, Campbell and Jaasted (1963) utilized "48 research scientists and 48 advertising personnel employed with the Minnesota, Mining and Manufacturing Company" (p. 30). They found nominal groups superior to real interacting groups. Furthermore the researchers compared two different combinations of group and individual brainstorming: (1) groups then individual, and (2) individual then group. They found the group-individual order of brainstorming more productive of numbers of different ideas (p.<.05) for research personnel and more productive of higher quality ideas (p.<.05) for advertising personnel (the other group under study).

Parloff and Handlon (1964) utilized three sets of instructions which primarily adjusted the degree to which subjects were critical of their own ideas. "The low critical conditions were essentially the same as brainstorming, stressing the avoidance of criticism and urging subjects to give their imaginations free rein". The high-critical conditions stressed the advantages of doing one's best and urged subjects "to analyze and scrutinize carefully each idea in order to select only the 'good' ideas" (p. 21). The problems chose included the following:

1. How can we solve the teacher shortage?
2. How can a shy girl go about meeting a boy she regularly sees on the bus?

3. How can foreign tourists be encouraged to visit the United States?

4. What would the consequences be of having an extra thumb on each hand?

5. What would the probable results be of mutation that would increase rate of physical maturation but not mental maturation?

6. What would be the advantages and disadvantages of having the power to read minds regardless of distance?

The results were divided into total numbers of solutions and total "good" solutions both written and unwritten. The results are replicated below.

<table>
<thead>
<tr>
<th></th>
<th>low critical</th>
<th>high critical</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>brainstorming</td>
<td></td>
</tr>
<tr>
<td>written</td>
<td></td>
<td></td>
</tr>
<tr>
<td>total ideas</td>
<td>230</td>
<td>377</td>
</tr>
<tr>
<td>&quot;good&quot; ideas</td>
<td>47</td>
<td>73</td>
</tr>
<tr>
<td></td>
<td>147</td>
<td>192</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>67</td>
</tr>
<tr>
<td></td>
<td>377</td>
<td>234</td>
</tr>
<tr>
<td></td>
<td>73</td>
<td>88</td>
</tr>
</tbody>
</table>

The key comparison to be made is between the total number of good ideas with brainstorming and the total number of good ideas under the high critical condition (73 and 88 respectively). These two numbers aren't significantly different. Note also however the large interaction between condition and recording method. When subjects were induced to drop criticism they recorded many more of their ideas. When they were induced to be critical they stated but left unwritten many more of their ideas. Parloff and Handlon observed "that under the high critical condition good ideas were frequently dismissed as inconsequential or inappropriate by other team members. Frequently ideas were put forth in so tentative a manner that the recorder made no effort to report them, apparently on the assumption that they were not worthy of serious consideration" (p. 25). The implication here is that brainstorming merely
helps overcome judgemental and recording problems but does not actually increase the number of good ideas to be put forth.

Brilhart and Jochem (1964) compared the two problem-solving patterns: ideation-evaluation and criteria-ideation. It was the former pattern which was regarded by Osborn as being essential to brainstorming. A third pattern entitled "problem-solution" was also tested. In this condition ideation and evaluation were combined. The combined problem-solving step was as follows:

How should we solve this problem? What are the relative merits of the ideas we can think of?.... if the group runs dry... ask "Are there any other ideas we ought to discuss?"

The separated instructions emphasized: going for wilder ideas, quantity, combination and improvement of ideas. There were three problems all of which were realistic: a library problem, the tourist problem and the teacher problem. The mean numbers of good ideas produced were:

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Good Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (ideation-evaluation)</td>
<td>4.37</td>
</tr>
<tr>
<td>B (criteria-ideation)</td>
<td>3.67</td>
</tr>
<tr>
<td>C (combined ideation and evaluation)</td>
<td>3.11</td>
</tr>
</tbody>
</table>

Pattern A yielded significantly more good ideas than pattern C (p. .01).

The results tend to lend support to both the order of ideation - judgement (deferred judgement) and the separation of the two processes although additional research is needed.

Gerlarch, Schutz, Baker and Mazer (1964) tested the proposition "that previously reported effects of 'brainstorming' on 'creative problem-solving' may be artifacts of the test directions. The authors utilized six different sets of directions to aid the subjects in solving the coathanger and broom uses problems. The number of "good" (jointly unique and valuable) responses is written beside each set of directions
as is the total number of responses given.

<table>
<thead>
<tr>
<th>Sets of directions</th>
<th>total responses</th>
<th>&quot;good&quot; responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. ...list all the possible uses you can think up...</td>
<td>11.90</td>
<td>4.55</td>
</tr>
<tr>
<td>2. ...list all the ideas that come to your mind without judging them in any way.</td>
<td>14.90</td>
<td>6.05</td>
</tr>
<tr>
<td>Forget about quality of the ideas entirely. We count only quantity...you may</td>
<td></td>
<td></td>
</tr>
<tr>
<td>combine or modify any</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Your score will be the total number of good ideas. Don't put down an idea</td>
<td>11.42</td>
<td>5.11</td>
</tr>
<tr>
<td>unless you feel it is a good one.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. We want to see how many good ideas you can produce in a certain amount of time.</td>
<td>11.16</td>
<td>4.05</td>
</tr>
<tr>
<td>You are going to be penalized for any bad ideas. Any ideas rated as poor will</td>
<td></td>
<td></td>
</tr>
<tr>
<td>be subtracted from your score.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. This is a test of creativity and originality...The more imaginative or creative</td>
<td>15.95</td>
<td>9.00</td>
</tr>
<tr>
<td>your ideas, the higher your score will be. Each idea will be scored in terms of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1) how unique or different it is - how much it differs from the common use and</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(2) how valuable it is - either socially, artistically, economically etc....</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. (brainstorming directions above followed by evaluation instructions similar to</td>
<td>17.07</td>
<td>7.86</td>
</tr>
<tr>
<td>5 above) (n.b. - the subject only read the evaluation instructions after the</td>
<td></td>
<td></td>
</tr>
<tr>
<td>response production time period)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The subjects had been given nine minutes to respond to a uses problem. Analysis of good responses were analyzed by three minute groupings. The results of this analysis did not support the hypothesis of monotonically increasing good responses through time. The authors concluded that when test directions include appropriate cues on evaluation criteria the superiority of brainstorming is not confirmed.

Turner and Rains (1965) found significantly higher quality ideas \((p<.01)\) could be produced with brainstorming than with standard instructions on the coathanger uses problem.

Campbell (1968) again verified the superiority of nominal groups over interacting groups, this time using Maier's Change of Work Procedures problem. Moreover it was found that when individuals were given the opportunity to participate in a preliminary group discussion of the problem prior to making a decision, performance was not improved.

Gurman (1968) also found nominal groups superior to real groups. In addition, he tested the effects of three different orientations to group work: self-orientation, interaction-orientation and task-orientation. Eighteen groups were homogeneous in orientation and eighteen heterogeneous. Orientation made no difference to performance.

Bouchard (1969) asks the question "under what conditions is individual brainstorming to be preferred to group brainstorming and vice versa?" The study was concerned with the effects of altering the groups brainstorming effectiveness. The author ran an individual-individual and group-individual condition in his first experiment. Under the individual-individual condition the subjects were given twenty minutes to work on each of two problems whereas under the group-individual condition subjects group-brainstormed for ten minutes and then worked individually for a further ten minutes. The
individual-individual condition proved only to be directionally superior to the group-individual condition in the number of good ideas produced. In the second experiment the author tested the effect of feedback upon group performance. The feedback group worked for five minutes on a problem then listened to the tape of the interaction and then continued work for another ten minutes. Feedback did not affect the number of good ideas arising in the session. Personality data was collected and it was found that factor 1 of the California Psychological Inventory (interpersonal effectiveness) and the C.P.I. Sociability Scale were both related to group brainstorming effectiveness. The author concludes that "high scoring subjects in the brainstorming groups have well developed social skills, are outgoing, enterprising, original, verbally fluent, fluent in thought, somewhat aggressive, dominant and controlling, and yet are concerned with feelings of others. They possess self-assurance and are spontaneous, expressive and enthusiastic" (p. 26). What is more, it was found in both experiments that individual brainstormers significantly outperformed group brainstormers. Furthermore, a combined ideation-judgement group problem-solving strategy was contrasted with a group brainstorming. Group brainstorming resulted in significantly more "good ideas" (p. < .01). Finally it was noted that performance (number of good ideas produced) decreased chronologically with the time spent on the problem.

Rotter and Portugal (1969) tested combinations of individual and group brainstorming. For sixteen minutes subjects worked entirely as individuals (I) or groups (G) or they spent eight minutes alone and eight minutes in groups (G-I and I-G). The individual problem-solving was more productive in the generation of different solutions than was group problem-solving. (p. .01)
The mixed conditions were of intermediate effectiveness. Moreover the individual phase of the mixed condition period was nearly twice as productive of ideas as was the group phase.

Bouchard and Hare (1970) found that the relative superiority of nominal groups over real groups increased with group size. The dependent measure was the number of distinct ideas produced.

Bouchard (1971) found personal analogy to be significantly more productive of large numbers of solutions than brainstorming.*

Bouchard (1972) compared the effect of training, motivation, and group composition on the performance of brainstorming groups. None of the main effects of these three variables contributed significantly to group performance. A change in the group brainstorming instructions, however, had the apparent effect of increasing group productivity. Bouchard required that each group member respond in sequence and to say 'pass' if he had nothing to say.

Dillon, Graham and Aidells (1972) also confirmed the superiority of nominal over real groups on a very realistic problem:

Given the current situation of an escalation of the war (Vietnam) and the widespread intense reactions across the country, what can you do as an individual to effect change, and what things would you change?

The number of distinct ideas generated was the dependent measure chosen. A videotape training and a practice effect both failed to materialize as main effects.

Bouchard, Barsaloux and Drauden (1974) combined brainstorming with the modelling technique for the purposes of this experiment: The subjects were given the 'consequences of universal blindness' question either under a lights-out or a lights-on condition. Under the lights-out condition the room was

* See page 61
gradually reduced to pitch blackness. Contrary to expectation the lights-on condition produced the greater number of ideas. Moreover, the nominal versus real group performance effects were again confirmed. Finally there was no main effect of sex on performance although the authors were able to reach the amusing conclusion that: "women performed better than men under the lights-on condition, while men performed better than women in the lights-off condition" (p. 137). Moreover Bouchard found that "seven-person nominal groups out-performed four-person nominal groups, but there was no size effect for real groups" (p. 135).

In conclusion then what is known regarding the effectiveness of brainstorming? Several aspects of effectiveness must be individually considered in order to obtain a well rounded understanding of the intent and significance of brainstorming research to date. An attempt will be made to answer the following six questions:

1. Does brainstorming work?
2. If it works, why does it work?
3. Under what conditions does it work?
4. What conditions account for the varying effectiveness of brainstorming?
5. What is the relative effectiveness of brainstorming in comparison with creativity stimulation techniques?
6. How might brainstorming be effectively altered or combined and synthesized with other techniques?

2.1.1 Does brainstorming work?

Of the thirteen studies which allow some conclusions to be drawn on the relative effectiveness of brainstorming as a creativity stimulation technique eight are inconclusive for one reason or another. The Chorness (1958) article is incomplete but what is known suggests the brainstorming treatment was confounded by other course instructions. Meadow and Parnes (1959) also confounded the brainstorming treatment with the remainder of a course on
creative problem-solving. Meadow, Parnes and Reese (1959) utilized inhibiting control group instructions. Parnes and Meadow (1960) gave brainstorming instructions to neither group before being tested. One group had received training in brainstorming as part of a course in creativity and that in itself constituted the difference between the two groups. Weisskopf-Joelson and Eliseo (1961) utilized what appears to be a suspect system for classifying "high quality" ideas. Finally, Bouchard (1971) utilized number of responses rather than a measure of creativity to score performance.

Of the remaining six studies, four were supportive of the superiority of brainstorming. Parnes and Meadow (1959) found brainstorming superior in producing high quality scores on the hanger and broom uses problem (p.<.001). Brilhart and Jochem (1964) found that the separation of ideation and judgement (brainstorming) resulted in higher scores on program creation problems than combined ideation-judgement instructions. (p.<.01). Turner and Rains (1965) also found significantly higher quality ideas could be produced by brainstorming the coat hanger uses problem (p.<.01). Finally Bouchard (1969) again found that the separation of ideation and judgement was conducive to the production of more good ideas upon consequences and program creation problems (p.<.01). To the contrary, Parloff and Handlon (1964) found no difference in performance between high critical groups and low critical groups (brainstormers) in the overall number of good responses generated upon program creation and consequences problems. Furthermore, Gerlach, Schutz, Baker and Handlon (1964) were also unable to find a significant difference between brainstormers and subjects using standard instructions on the broom uses problem.

In summarizing the above information it would appear that brainstorming
is an effective technique for generating creative ideas. Four out of six studies testify to the superiority of brainstorming while two found essentially no difference between brainstorming and control conditions.

2.1.2 Why does brainstorming work?

A number of distinct possibilities have been suggested as reasons for the superiority of brainstorming:

H1: Because ideation and judgement are separated under brainstorming. Two studies provide evidence in support of this hypothesis, namely; Brilhart and Jochem (1964) and Bouchard (1969). On the other hand, Gerlach et al (1964) found combined brainstorming and criteria cueing instructions resulted in directionally better quality solutions than simple brainstorming instructions.

H2: Because judgement is deferred (ideation precedes judgement). Only the most tentative directional support is presented in favor of this proposition (Brilhart and Jochen, 1964).

H3: Because brainstorming requires that all ideas must be recorded during ideation. In support of this proposition Parloff and Handlon (1964) found that brainstormers produced significantly more "good" written ideas but significantly fewer "good" verbally recorded ideas than non-brainstormers.

H4: Because brainstorming stresses the importance of producing a large number of ideas with statements like "go for quantity". Of the six studies listed above as constituting good tests of brainstorming* the control conditions of four contained injunctions that the subject should emphasize quantity. A fifth study contained an implicit demand for quantity for both treatment conditions (Parloff and Handlon, 1964) but in the sixth study

* See page
only brainstormers were requested to go for quantity (Brilhart and Jochem, 1964). Where both control conditions and brainstorming stated that quantity was desired, brainstorming was significantly superior in three out of the four cases. It therefore seems plausible that brainstorming effectiveness relies upon more than a request for quantity.

H5: Because brainstorming is merely a free association technique which works by ordering subjects to "think wildly". Evidence to the contrary was generated by Manske and Davis (1968). They found neutral instructions and requests to "be practical" resulted in more good ideas than instructions to "think wildly".

2.1.3 Under what conditions does brainstorming work?

The four unambiguously successful studies which tested brainstorming are herein analyzed to see what can be said about the characteristics of situations where brainstorming is effective. The four studies again are: Parnes and Meadows (1959), Brilhart and Jochem (1964), Turner and Rains (1965) and Bouchard (1969).

First of all, the successful tests of brainstorming have been conducted upon university students in experimental settings.

Secondly, the problems given subjects require between five and thirty minutes to complete.

Thirdly, the brainstorming subjects have been successful with unusual uses problems, with consequences problems and with program creation problems.

2.1.4 What conditions account for the varying effectiveness of brainstorming?

It has been decisively demonstrated that nominal groups outperform real groups (Taylor, Berry and Block, 1958; Dunnette, Campbell and Jaasted, 1963;
Evidence to the contrary was reported by Shaw (1971) who states that Rosenbaum (no date or source given) found that when the brainstorming session was extended in time the real groups outperformed the nominal groups.

Moreover it has been demonstrated that by increasing group size one adds little to real groups productivity (number of ideas produced) whereas nominal group productivity may be augmented substantially (Bouchard and Hare, 1970; Bouchard, Barsaloux and Drauden, 1974).

Thirdly, personality and group composition variables have sometimes been found to alter the effectiveness of brainstorming. Cohen et. al. (1960) found groups that were formed of high sociometric-choice partners outperformed the low sociometric-choice partners. Gurman (1968) was unable to demonstrate that the problem-solvers orientation to group work (self-, interaction- or task-orientation) would affect group performance. In 1969, Bouchard found that interpersonal effectiveness and sociability were correlates of brainstorming productivity. In 1972 an experimental manipulation of individuals into high and low interpersonal effectiveness groupings failed to have a main effect upon productivity. In 1972 and again in 1974, Bouchard and co-researchers failed to demonstrate a main effect due to subject sex upon productivity.

Fourthly, researchers have attempted to find the effectiveness of training upon brainstorming performance. Four studies relate directly to training effectiveness (Parnes and Meadows, 1959; Bouchard, 1969; Bouchard, 1972 and Dillon et al, 1972). Parnes and Meadows (1969) found course trained subjects significantly more effective in producing both more quantity and
higher quality of ideas than subjects utilizing brainstorming instructions for the first time. Bouchard (1969) was unable to influence the number of good ideas produced with a feedback session. Moreover Bouchard (1972) found prior practice brainstorming on three sets of problems did not increase performance. Finally, Dillon et al (1972) failed to produce a performance increment either by videotape training or by practice.

2.1.5 How might brainstorming be altered or combined and synthesized with other techniques to increase its effectiveness?

The brainstorming technique has undergone only minor alterations since it was originally conceived by Osborn in 1957. Firstly, researchers have demonstrated the superiority of nominal over real group performance. Secondly, they have attempted to combine individual and group brainstorming in such a mix as to increase effectiveness over the nominal group condition (Dunnette et al, 1963; Campbell, 1968; Bouchard, 1969; and Rotter and Portugal, 1969). Further, they have attempted to combine brainstorming with other techniques (Gerlach, et al, 1964; Bouchard, 1974) and finally to alter the manner in which the group members emit ideas (Bouchard, 1972).

Dunnette, Campbell and Jaastad (1963) had some subjects work first in an individual condition and then secondly in a group condition. The order of the treatments was reversed for other subjects. The researchers found a larger number of good ideas resulted when group brainstorming preceded individual brainstorming (p.<.05) with research personnel but not with advertising personnel. In a subsequent experiment, Campbell (1968) found that prior group discussion did not improve individual problem-solving performance. Bouchard (1969) replicated the Dunnette et al. (1963) design and yielded similar results for one of two sets of problems (p.<.05). A total brainstorming
session was also found superior when group brainstorming preceded individual brainstorming. In a third experiment Rotter and Portugal (1969) found with one problem, group brainstorming preceding individual brainstorming was superior and with the other problem, inferior. Therefore there is some evidence in favor of utilizing first a group and then secondly an individual brainstorming session over the alternative of individual then group brainstorming.

Gerlach et al (1964) combined brainstorming instructions with evaluation criteria instructions and produced essentially the same number of ideas as with brainstorming or criteria cueing separately. Bouchard et al (1974) combined brainstorming with modelling of the problem situation and found a decrement in performance (p < .01) resulting from adding modelling to brainstorming.

Bouchard (1972) suggested an adaptation to group brainstorming wherein the subjects were required to contribute their ideas in sequence and to "pass" if they had nothing to add. Such a procedure seemingly augmented the number of answers produced by this method to twice the number which had been produced in an earlier experiment under similar conditions.

2.1.6 What is the relative effectiveness of brainstorming to other creativity stimulation techniques?

Only two studies have been conducted which compare brainstorming with other techniques. In 1964, Brilhart and Jochem found instructions on evaluation criteria (final state elaboration) directionally superior to brainstorming instructions. In 1971, Bouchard found personal analogy instructions significantly more effective than brainstorming instructions in producing numbers of ideas.
2.2 Free Association

Eight studies were found which related to free association as a creativity stimulation technique.

Maltzman, Bogartz and Breger (1958) presented treatment subjects with lists of words with which to free associate. They were told to respond differently to the list of words for each of five repetitions of the list. The control group was only required to respond to one presentation of the list with the first words which came to mind. Measures of originality, not creativity were used to evaluate performance. Free association training resulted in slightly less than a significant increase in the number of uncommon responses evoked by the word association test list (.05 < p < .10). Ambiguous results were obtained upon an unusual uses test.

Maltzman, Brooks, Bogartz and Summers (1958) investigated the hypothesis that "if relatively uncommon responses are elicited even though they don't enter into the solution of a subsequent problem, their elicitation would facilitate the occurrence of a problem solution" (p. 399). Maier's two string problem was chosen as the task problem. The time used to solve the problem was the measure of performance used. The subjects were induced to write as many uses as they could for various objects in the first experiment. In a second experiment subjects were given lists of paired uses for objects and asked to "check which member of each pair they would be more likely to use" (p. 402). "Partial confirmation of the hypothesis was obtained" (p. 405).

Maltzman, Simon, Raskin and Licht (1960) reported upon a series of experiments which were intended to determine the essential features of a procedure for facilitating original responses. The procedure researched
was the "standard experimental training procedure of repeatedly evoking different responses to the same stimuli" (p. 16). The research revealed this technique to be the most successful of three experimental procedures tried, and moreover, highly reliable in producing an increase in uncommon responses on two different tests of originality. It was also found that the effects of originality training may persist for as long as two days and that originality as measured by the free association test varies as a function of the number of repetitions of the training list (p. 16).

Anderson and Anderson (1963) intensively trained his experimental subjects to recognize many of the physical attributes of various objects. Each of thirty-six grade school boys spent thirty minutes in a group with three other boys and the instructor. "At each session the subjects were shown different objects, one at a time. Instructions were to 'name as many uses as you can' for each object" (p. 301). The experimenter would spur the subjects with a list of attributes for each object. "When the subjects stopped responding, the experiment might say, to illustrate,

So far the uses you have named involve length, strength, hardness. Are there any other things about this ________ that suggest use to you?" (p. 301).

After training, a novel uses test was administered. Responses were rated inversely to their frequency of occurrence. (The authors used a sample of 55 other subjects to norm the response of frequency of uses). The mean originality score was significantly higher for trained than for control subjects (p.<.001). On the following day all subjects were asked to solve three insight problems. The treatment subjects outperformed the controls on the sum of the scores of the three problems at about a .05 level of significance which suggests that association training may aid performance
upon insight problems.

Caron, Unger and Parloff (1963) tested Maltzman's hypothesis that standard word-association training increases the number of 'relevant' uncommon responses given to various stimuli. The authors concluded that word association training should enhance performance on Mednich's Remote Associates Test if the number of 'relevant' uncommon responses is actually being increased. However, the training was found to be ineffective. The researchers suggested that a 1961 conclusion of Maltzman's might aptly explain their findings:

Since there are a large number of uncommon responses that may be prompted in any one associative response hierarchy, the probability of occurrence of a specific uncommon response appropriate to a problem would be increased only slightly if at all.

Rosenbaum, Arenson and Panman (1964) found that Maltzman's training procedure "is effective in facilitating the production of original responses on subsequent tasks".

Freedman (1965) developed his own free association procedure to improve performance upon the Remote Associates Test of Creativity. "The facilitation group was instructed to give their associations to each of 10 stimulus words. Each word was read aloud by E and S was told to give whatever words come into his mind, and to continue until told to stop. They were stopped after 30 seconds or when they had stopped responding. The non-trained group significantly outperformed the non-control group on the R.A.T. test (p.<.01).

Gall and Mendelsohn (1967) had subjects do the Remote Associates Test. The treatment subjects were then required to free associate for twenty-five minutes "to the words comprising the (first) five problems
they had missed. Each card was presented separately to the subject and he was asked to give an associate to each of the three words regardless of whether he thought the associate was the answer word or not...then the sequence was repeated...if the subject repeated an association he was asked to give another in its place...After the twenty-five minutes were up, the subject was asked to work on the problems he had not yet solved, again for a period of two minutes each" (p. 213). The control condition had subjects work on a completely unrelated task (a non-verbal task) for the twenty-five minute interim period. The free association experience resulted in significantly more R.A.T. solutions given by females only (p.<.01).

Ridley and Birney (1967) found that word association training (Maltzman's instructions) was useful in increasing the number of unique uses generated on a Unique Uses Test (p.<.05) and the number of original titles on the Plot Titles Test (p.<.01).

Miller, Russ, Gibson and Hall (1970) replicated Freedman's study* and produced conflicting results. In their first experiment they were unable to produce a significant effect upon the R.A.T. test with free association training. However in a second experiment a significant effect upon R.A.T. scores resulted due to the same kind of training.

In summary the research has generated very mixed results upon the effectiveness of free association as a creativity stimulation technique. Anderson and Anderson (1963) produced a barely significant change in the number of solutions given to insight problems by free association trained subjects. Caron et al. (1963) were unable to increase creativity scores upon R.A.T. as a result of training. Freedman (1965), however, did produce an increased R.A.T. score by training. Gall and Mendelsohn (1967)

* see above, page 46.
were able to increase R.A.T. performance for females only. And finally, Miller et al. (1970) found an increase in R.A.T. score as a result of association training in only one of two experiments.

2.3 Final State Elaboration

Nine published empirical studies were found which attempted to focus the problem-solver's attention upon the nature of the potential solution. Christenson, Guilford and Wilson (1957) found that subjects produced a significantly greater number of clever responses when asked to write "clever" ideas rather than "appropriate" ideas with the plot titles problem (p.<.01).

Hyman (1961) utilized thirty-six newly-hired male engineers and a very realistic industrial problem*, to test the relative effectiveness of a "constructive" and a "critical" problem-solving set. Subjects were either asked to "list as many good features and benefits" or as many "faults and problem" with a presupplied list of possible answers (In effect, the subjects were exploring the characteristics of a good or poor solution, respectively). The subjects were then asked to propose their own solutions to this same problem. "For this problem the subject gave his responses in two stages of phases: in the production phase S was asked to list as many ways as possible to recognize the boxes (10 minutes); in the Solution Phase, he was asked to choose his best solution and briefly develop it in

* This problem "originated as an actual manufacturing task of a component of the General Electric Company" (p. 152). "In brief, the Automatic Warehousing Problem requires S to devise a system which would automatically recognize boxes to comply with certain specifications" (p. 154).
more detail (10 minutes)...As a final task, S was asked to devise an application for the Pyroelectric Effect...which is a little known physical phenomenon" (p.154). In the latter problem, the production phase was ten minutes and the solution phase, five minutes. Ratings of solutions were by engineers and inter-rater reliabilities were .85 for the first problem and .86 (adjusted) for the second problem. The "constructive" set proved helpful in both the first problem (p.<.05) and the transfer problem (p.<.05).

Hyman further reported upon two related unpublished studies by Torrance and an associate. "As an assignment in an educational psychology class, Torrance (1959), instructed half his class to review 'creatively', articles in professional journals, i.e. to look for new possibilities in the reported findings. He instructed the other half of his class to review 'critically', articles in the professional journals, i.e., to point out defects and limitations. The effects of the "creative" assignment apparently carried over to the students' individual term projects which were rated significantly more creative than those turned in by students in the critical condition" (p. 158).

Johnson and Zerbolio (1964) asked subjects to write down "clever" or "appropriate" titles to plots in the manner of Christenson et al (1957).* The difference between treatments were negligible on ratings of 'cleverness' and 'high quality'.

Gerlach, Schutz, Baker and Mazer (1964) found criteria cued instructions** to be directionally more effective than brainstorming instructions and significantly more effective than neutral instructions. The criteria cued instructions were as follows:

* above, page 48.
**see page 32.
This is a test of creativity and originality...the more imaginative or creative your ideas, the higher your score will be. Each idea will be scored in terms of (1) how unique or different it is - how much it differs from common use and (2) how valuable it is - either socially, artistically, economically, etc... (p. 80).

Manske and Davis (1968) demonstrated that although subjects could produce either significantly more practical ideas when asked to "be practical" or significantly more original ideas when asked to "be original", they were unable to increase responses which were simultaneously both practical and original.

Johnson, Parrott and Stratton (1968) performed two experiments in which they compared the effectiveness of criteria cued instructions for improving subject creativity. The subjects were first told to attempt "good" or "clever" solutions to problems. More specific criteria were then elaborated for each of the five problem types to which the subject was exposed:

- **Plot Titles.** By clever we mean an imaginative creative or unusual title for this plot.
- **Table Titles.** A good title is a comprehensive one which includes the important points concisely.
- **Conclusions.** A good conclusion would be a valid generalization which integrates the table as a whole.
- **Sentences.** A good sentence reads smoothly; the four words fit in unobtrusively into the structure of the sentence.
- **Cartoon.** A clever quote is an imaginative idea that fits the cartoon.

In experiment the effect of criteria-cued instructions was to increase the total number of superior responses produced on all five problems together (p.<.05). In experiment 2, criteria cueing did not make a significant addition to the quality of the single solutions written although the mean quality of the criteria cued group was slightly higher.
Colgrove (1968) gave experimental subjects the following additional instructions when they were faced with Maier's Change of Work Process problem:

You have the reputation of being a very original person and of being good at coming up with answers to difficult problems... Keep this in mind when studying the problem (p. 1208).

As it turned out, experimental subjects produced substantially more high quality integrative solutions than had control subjects. (p.<.005).

Stratton, Parrott, and Johnson (1970) designed an experiment to test the hypothesis that "judgement training would increase production quality" (p. 17). Judgement was trained by using a twelve item multiple choice test wherein subjects were asked "to select the 'best' solution of five for each item. Test items were of varying difficulty" (p. 17). Ten minutes was allowed for training. It was found that judgement training improved the number of "preferred solutions" for groups producing only single answers to problems (p.<.01) and for groups producing multiple answers to problems (p.<.01).

Stratton and Brown (1972) observed from previous research that "training in the evaluation of completed solutions (judgement training) increases quality but decreases productivity, and training in idea generating techniques (production training) increases productivity but decreases quality. (Their) study compared the separate and combined effects of these seemingly incompatible forms of training" (p. 309). Plot title problems were used to measure creativity in this research. Judgement training "consisted of a description of the plot title rating procedure and the criteria used by the judges. Examples and explanations were given for poor, mediocre, and superior titles. Practice in selecting the best of three titles was supplemented by immediate feedback, and finally, subjects were given an
opportunity to verbally state their own criteria for a good title" (p. 392).

Four experimental conditions were used in this research: (1) control instructions (emphasizing the desirability of clever solutions), (2) judgement training, (3) morphological synthesis, and (4) combined judgement training and morphological syntheses. The number of superior solutions produced by subjects indicates the superiority of all treatment conditions over the control condition (p. .05). However, the treatment conditions were insignificantly different, one to the other.

In summary then, four studies have attempted to demonstrate that creativity can be produced on demand, assuming that a simple request to be clever, original or creative was all that is needed. Christenson et al (1957) first discovered that a request to be clever resulted in more clever responses. Johnson and Zerbolio (1964) failed to replicate the "be clever" effect in a very comparable experiment. Manske and Davis (1968) were unable to facilitate the production of ideas which were jointly original and practical, or in other words, creative. Colgorve (1968), on the other hand, was able to produce more creative solutions to a problem by suggesting to the subject that he was a competent and original problem-solver. It is possible, however, that the request to "original" was confounded by instructions which the researcher admit to being "designed to foster confidence in (the subjects) problem-solving ability" (p. 1205). In summary, only the first of the four studies unambiguously supports the hypothesis that creativity can be generated upon request.

Two other studies attempted a more complete operationalization of evaluation criteria. Gerlach et al. (1964) found that a single paragraph description of a creative response was adequate to produce significantly more creative ideas than could be produced by neutral instructions. Moreover, Johnson et al (1968) found that a description of the nature of good or clever solutions relevant to each specific problem was all that was necessary to increase the number of superior solutions to those problems.
2.4 Initial State Elaboration

Nine studies were found which bore on the creative effectiveness of initial state elaboration. A problem-solver might elaborate upon the information describing the current state of the problem situation in a number of ways. He may choose to utilize attribute listing, a checklist, a set of heuristics, forced comparison and/or forced completion.

Hyman (1961)* described an unpublished study by Torrance and Harmon (1960) wherein the researchers demonstrated that students utilizing a "creative application" set for reading their assignments outperformed others using a "memory" or "evaluation" set on creative applications.

In 1961 Torrance tested Osborn's creativity checklist on a product adaptation problem with primary school children. Osborn's checklist included 18 questions such as:

What would happen if we made it larger?

and

What would happen if we changed the shape?

Training sessions lasted twenty minutes in which time the children were introduced to the idea spurring questions. The results demonstrated that "the effects of training (were) statistically significant at better than the five per cent level of confidence for the second and third grades but not for the first. These results hold for all ratings scores: fluency (number of ideas), flexibility (number of approaches), cleverness, and total" (p. 38).

Maier and Solem (1962) tested the relative effectivenss of problem-mindedness versus solutions-mindedness. Subjects in the problem-minded condition were asked to utilize a special three step problem-solving procedures:

* see also page 48.
Step 1: Present the problem and then conduct a brief general discussion to obtain an expression of everyone's views on the problem.

Step 2: After the initial airing of viewpoints, conduct a discussion in your group for the purpose of exploring the important factors in the problem and develop a written list of these factors.

Step 3: After all important factors have been listed, use the list as a basis for group discussion in deciding on the solution.

The solution-minded group (control group) received only the standard instructions which normally accompany Maier's Change of Work Procedures Problem. The experiment utilized both college students (N=66 groups) and management personnel (N=80 groups). The experimental groups outperformed the control groups with both the students (p.<.05) and the managers (p.<.01).

Cartledge and Krauser (1963) replicated the Torrance (1961) study*, this time with 120 grade one school children. The treatment consisted in training the subjects in the use of Osborn's checklist over twenty-five minute sessions - Monday through Friday. The produce improvement test was administered both before and after training. Creativity ratings were a composite of scores upon ideational fluency, flexibility and originality. Difference scores between the first and second testings were used to calculate the effectiveness of training. It was found that "training results in a superior average creativity score compared with no training." (p. 297).

Ridley and Birney (1967) provided five sets of heuristics (checklists) for suggesting unusual uses. For example, on set of heuristics states: "Transform the object: burn it, cut it, paint it, etc. What uses of your objects do these transformations suggest?" (p. 159). The heuristics training resulted in significantly more unusual uses than did control instructions (p.<.001). Furthermore the heuristics trained group

*above, page 53.
next outperformed the others upon a plot titles test (p. < .05) - a finding which was not expected.

Davis and Roweton (1968) expanded upon some unpublished research by Train in 1967. Train had found that a list of 55 of Osborn's 73 idea-spurring questions was ineffective in stimulating ideas for "changing or improving" with a car, an office desk, or a kitchen sink when subjects were given ten minutes to work on each of the three problems. In a second experiment, subjects using checklists were found again not to be superior to controls when given twenty minutes to list changes and improvements for each a cup and a kitchen sink. In a third experiment, Train again found the checklist not to be useful even when it was greatly expanded. Subsequently, Davis and Roweton reduced the checklist to the following: a) Add and and/or Subtract Something, b) Change Color, c) Change the Materials, d) Change by Rearranging the Parts, e) Change Shape, f) Change Size, and g) Change Design or Style. The authors, this time however, found the checklist treated subjects to be significantly superior on various dependent measures, including the number of above-average creative ideas on problem: thumb tack changes problem (p. .01) and kitchen sink changes problem (p. .01).

Warren and Davis (1969) tested the relative effectiveness of both long and short checklists against controls. The 30 S's involved were asked to "produce as many ideas as you can that may be used as physical changes and/or improvements for a door knob". Neither checklist statistically outperformed the control on a measure of creativity (all ideas above the midpoint on both practicality and originality).

Roweton (1969) either required subjects to study a seven item checklist only during the preproblem, instructional period or allowed them to keep the checklist throughout the entire problem-solving part of the
experiment. There was no significant difference in effects between the two modes of employing a checklist.

Khatena (1971) utilized three creative thinking strategies, (all designed to modify initial state conception) to encourage creativity upon the figural forms portion of the Torrance Test of Creativity. The author utilized 140 children from seven preschool classes as subjects for this experiment. The techniques were entitled: breaking away from the obvious and commonplace, restructuring, and synthesis. The first technique "required them to break away from the perceptual set of a square by making other common objects like the window or door". In training for a second technique, restructuring, the subjects were allowed to use only three triangles, four rectangles and four semi-circles which had been structured as a man. "They were taught to restructure this picture into that of a car... . Training for synthesis allowed the subjects to use all thirty pieces (eg various geometric shapes)...to make other pictures..." (p. 385). Significant gains were made from training upon fluency, flexibility, originality, and elaboration (p.<.05).

In conclusion initial state elaboration techniques have been overwhelmingly successful in increasing creativity. Only Torrance (1961) was unable to increase first grader creativity with a short Osborn checklist. However by lengthening the training period, Cartledge and Krauser did increase first grade creativity. The exception to effective initial state elaboration has to date been the extended checklist (Train, 1967; Warren and Davis, 1969).
2.5 **Incubation**

Three studies were found which relate to the effectiveness of incubation as a creativity stimulation technique.

Patrick (1938) contrasted the creative performance of groups planning an experiment. "One group planned the experiment at one sitting; the other group thought about it over a period of two or three weeks and kept a diary, in which they recorded any thoughts, which they had concerning the problem during that time" (p. 56). "The average ratings by all three judges were higher for the final products of the (incubation) group than for the final products of the (control) group" (p. 71). The differences were significant at the .01, .02 and .33 levels of significance for each of the three judges.

Gall and Mendelsohn (1967) tested the relative effectiveness of induced incubation where a subject's attention had been diverted for a time as contrasted with continued work on the problem. All subjects were given the R.A.T. test (30 items). Subjects were told "You are to work on a problem until you solve it or two minutes have passed. Feel free to guess". (p. 212). The first five problems each subject failed to solve were then set aside. The incubation groups were then asked to make psychophysical judgements about weights for 25 minutes. "After 25 minutes had elapsed, the subject was told "I want you to work again on some problems that you previously missed. As before you will have two minutes for each problem and you can feel free to guess" (p. 213). The control group had a full 5 minutes to work on each of the problems initially then 2 additional minutes to work upon each of the problems missed. The uninterrupted group significantly outperformed the incubation group.
Fulgosi and Guilford (1968) utilized consequences test items to measure subject fluency and subject originality. Subjects in the experimental condition worked on a problem for 2 minutes then filled in either 10 or 20 minute intervals with other unrelated work before spending another two minutes on the problem. Half the subjects were told that they would have a second opportunity to work on the items and half were not. The control subjects worked straight for four minutes on a problem. It was demonstrated that the ten minute interval yielded very little gain in production over the no interval condition but that the 20 minute interval yielded a significant gain. It made no difference whether S's were told that they would have additional time for the items. The gains were apparently greater for production of obvious consequences than remote ones.

In conclusion, it would appear from the research that continuous work on a problem at the point of impass would be more effective than an interruption composed of unrelated work (Gall and Mendelsohn, 1967). If the incubation is not to replace additional work on a problem but just to allow a breathing space upon unrelated work then incubation can be of value (Fulgosi and Guilford, 1968). Moreover by giving subjects an opportunity to think upon a difficult problem over a period of two or three weeks one can improve their performance over what it would have been from a one-shot problem-solving sitting (Patrick, 1938).

2.6 Modelling

Three studies were found where subjects were provided with a situation which was at least partially modelled for them.

Lorge, Tuckman, Aikman, Spiegel and Moss (1955) set up an experiment to test "the difference in the quality of the solution to a practical field problem presented in four settings differing in their degree of remoteness
from reality: (a) the verbal description, (b) the photographic representation, (c) the miniature scale model, but not allowing manipulation of parts and materials, (d) the miniature scale model allowing manipulation of parts and materials" (p. 17). The problem chosen for testing is the Mined Road Problem. A group of soldiers are required to quickly and obtrusively cross a road which has been mined. There are materials present at the sight which might be used in the solution. It was found that the levels of reality contributed insignificantly to the quality of answers generated.

Lorge, Tuckman, Aiken, Spiegel and Moss (1957) moved the Mined Road Problem from a laboratory to a field setting, again adjusting the levels of reality of the model. "The Mined Road Problem was constructed in reality in open country. Three variations were possible with a real field setting: (1) the actual real without manipulation, where men were not permitted to manipulate the beams, tires, ropes, etc. (2) the actual real with manipulation, where the men were permitted to manipulate all equipment but not to carry a solution to completion, and (3) the actual real solve, where the men were actually required to carry the solution to completion, i.e. to actually cross the road" (p. 161). The quality point score was not significantly different for the three levels of reality.

Bouchard, Barsaloux and Drauden (1974) had subjects provide solutions to the consequences of blindness problem either under a condition where blindness was modelled by required problem-solving in a blackened room. The subjects brainstormed significantly more effectively in the lights-on (unmodelled) condition, contrary to expectations.

In conclusion, the three studies which were conducted upon modelling all failed to demonstrate the effectiveness of modelling as a creativity
stimulation technique. In effect, one study even suggested modelling might inhibit creative problem-solving (Bouchard et al. 1974).

2.7 Analogy

Only two studies relating to analogy were found during the literature search. The first confounded the analogy treatment with other types of instructions (Khatena, 1970) and the second had a bearing upon only one specific kind of analogy (Bouchard, 1971).

Khatena (1970) instructed subjects in techniques which he called "breaking away from the obvious and commonplace, transposition, analogy, restructuring and syntheses"*. All experimental subjects received instructions and practice for a total of two hours in 2 one-hour sessions. The subjects in the experiment were students. It was found that training improved performance significantly in two tests of creativity: (1) an onomatopoeia and images test and (2) a sound and images test.

Bouchard (1971) utilized unusual uses problems, brand name problems, consequences problems and the tourist problem for a test of the relative effectiveness of brainstorming and personal analogy. The total number of ideas produced was the criterion of effectiveness. The analogy instructions required one member in each analogy using group to "get up on (a) table, sit down, close (his) eyes and play the (part of the object in the problem)" (p. 419). On four out of the nine problems personal analogy instructions resulted in significantly more ideas being produced (p. .05). Moreover, analogy users out-performed the brainstormers on the remaining five problems but to statistically insignificant degrees.

* nb, the transposition of ideas involves using ideas from analogous situations.
In conclusion it has been experimentally demonstrated that analogy may increase creativity on two tests of creative ability and that personal analogy can be used to generate large numbers of ideas for problem-solving.

2.8 Creative Process Heuristics

Creative Process Heuristics are sets of instructions informing the subject of the nature of the creative process and suggesting he emulate the creative process format. Creative Process Heuristics include such techniques as the two stage ideation-judgement strategy; multi-stage problem-solving formats (i.e. (1) problem awareness, (2) acceptance, (3) analysis, (4) definition, (5) ideation, (6) judgement and (7) elaboration); disjointed incrementalism; constraints elaboration, etc.

The evidence collected to date on the value of ideation-judgement (i.e. deferred judgement) are supportive of the technique of at least a two-stage model of creative problem-solving. Another technique which has received some testing to date is disjointed incrementalism. This technique requires that the subjects make incremental improvements in existing solutions. Maier and Solem (1960) required that subjects solve Maier's change of work procedures problem twice. The subjects were given twenty minutes to provide a first solution after which "the instructors asked the groups to resume discussion and obtain another solution to the problem" (p. 280). There were more high quality solutions resulting from the second problem-solving effort than from the first one. (p < .01). Apparently the second effort allowed subjects to make incremental improvements upon their answers given at the conclusion of the first session.

The second study on disjointed incrementalism was conducted in 1973 by S. Wheelwright and directed towards the corporate planning effectiveness.
Wheelwright's first control procedure consisted of instructions for the 'synoptic' or 'holistic decision-making process'. The problem-solving stages to be followed were:

(1) the identification and selection of those objectives and other values which the strategic planners believe should govern their choice of a corporate strategy;

(2) a consideration of the alternative strategies that could be adopted to achieve these objectives;

(3) the evaluation of these alternative strategies in terms of their abilities to meet the stated objectives:

(4) the selection of that alternative that will best accomplish the stated objective.

A second control group were given the option of formulating a strategy "by whatever manner they desired".

A third group were given the 'incremental' instructions following:

(1) the identification of the firm's existing strategy;

(2) the determination of the present strengths and weaknesses of the firm;

(3) the identification of the major threats and opportunities that the firm faces in its environment;

(4) the modification of the firm's existing strategy to better account for weaknesses in the firm and threats in the environment, and to take advantage of available resources and opportunities in the environment.

The subjects were approximately 165 end-year MBA students (in 25 groups) at the Stanford Graduate School of Business. The problems were three complex Harvard Policy Cases (the American Motors case; the HMH-Publishing case and the Mathatronics case.) All subjects solved all cases, used all techniques but the groups of subjects used the techniques in different sequences upon the three cases. A large number of dependent ratings variables were used in the analysis of the resulting strategies, such as:
- likelihood of achieving long-run objectives
- flexibility
- competitive advantage

The author concludes "from the judge's evaluations...the incremental procedure leads to better strategies than the synoptic procedure, but the synoptic leads to more varied strategies than the incremental" (p. 71). The control strategy was not rated by the judges but was generally thought to be better than the synoptics strategy but not as good as the incremental strategy by the subjects.

In conclusion then both the two stage ideation-judgement and the disjointed incremental technique have received initial support from the experimental research.

2.9 Forward Backward Problem-Solving

Only two studies were found which related to forward backward problem-solving.

W.S. Anthony (1966) set up an experiment for the purposes: (1) of obtaining simple observations of working forward and of working backwards; (2) to illustrate that an experimenter can determine the relative effectiveness of the two directions of work; and (3) to test for adaptive tendencies in the subject's direction of work. The problem chosen was a route finding problem considered by the author to be analogous to a maze problem. Two types of tasks were used. In tasks of type 'B', working backwards was relatively more effective. In tasks of type 'F' working forward was the relatively more effective problem-solving style. The subjects were given five 'training tasks' of one type followed by a 'reversal task' of the other. Anthony found that the subjects tended to start by working
forward (p.<.012). He also found that subjects performance was not significantly different when working forward or backward. Finally it appeared easier for subjects to go from a backwards direction to a forwards direction than visa versa.

Benjafield (1971) varied cues in such a way to make the likelihood of forward problem-solving higher than backward problem-solving and visa versa. The task required that subjects put a regular 'tetrahedron' together out of its component halves. The author increased some of the subjects' ability to accurately perceive the shapes by suspending them in the air rather than leaving them upon a table and by so doing increased the likelihood of a forward problem-solving approach. With other subjects the author varied the specificity of the goal by either telling the subjects to make an object which had four surfaces or be telling them to make a pyramid with four surfaces. Subjects were given 45 minutes to solve the problem but not allowed to give up until 20 minutes had elapsed. Both the clues to backwards problem-solving and the clue to forward problem-solving resulted in significantly more correct answers than the condition with no clues and insignificantly more correct answers than the situation with both forward and backward clues.

Other evidence was presented to convincingly demonstrate that backward clues actually induced backward problem-solving as did forward clues induce forward problem-solving. It should be noted that the effect that the forward and backward problem-solvers outperformed controls can be accounted for the provision of additional relevant problem information.

In summary, research to date indicates that subjects are willing and able to utilize backward as well as forward problem-solving strategies.
2.10 **Morphology**

Only two studies could be found which related to morphology as a creativity stimulation technique.

Warren and Davis (1969) operationalized morphology by explaining to subjects that "(1) a good way to think of variations and improvements for something is first to analyze the 'thing' into its various dimensions, then to combine the values of these dimensions into new arrangements (2) the very large number of ideas found in this fashion may be good themselves, or may act as hints for producing still other ideas. Examples were provided to clarify this procedure" (p. 210). With a problem requiring changes and improvements in a door knob, morphology users produced a greater average number of creative ideas* than did checklist users or control subjects:

<table>
<thead>
<tr>
<th>Average No. of Creative Ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morphology</td>
</tr>
<tr>
<td>Checklist: short</td>
</tr>
<tr>
<td>long</td>
</tr>
<tr>
<td>Control</td>
</tr>
</tbody>
</table>

F = 2.39 (p..10)

The above statistics were the only probability calculations presented upon the relative effectiveness of morphology. It would appear likely, however, that a t-test of difference between morphology and control subjects would indicate the superiority of morphology at least at the .05 level of significance.

Stratton and Brown (1972) utilized plot title tests with morphology users. Morphology-treated subjects were asked to "construct an idea table with one column for each major division or theme in the story. Within each

* Creative ideas were those rated above the midpoint on both originality and practicality.
column, subjects then list all related information from the story. Thus, all information related to the plot is systematically explicated and all possible combinations of major and minor details can be examined as potential titles. The training program consisted of an explanation of the technique, several examples of how it could be used, and practice in using it with the first plot title problem. The last part of this training consisted of reading the plot for the second problem and making an idea table for it. This was presented to the subjects as further practice in constructing idea tables, and there was no indication that this would be the next problem. When the subjects worked on the second problem, however, they were instructed to use this table" (p. 392). The number of superior solutions produced by morphology was significantly greater than the judgement trained subjects.

In conclusion, morphology has been demonstrated to be an effective technique with two different types of problems.


To the present brainstorming is the only technique that has been substantially investigated. Moreover, empirical research on brainstorming doesn't appear to be in any danger of disappearing in the near future.

The research upon 'initial state elaboration' and upon 'final state elaboration' have seemingly made the next most progress. Both techniques have been demonstrated effective. Unfortunately however, each of these techniques has escaped recognition as a unique strategy for stimulating creative problem-solving. This review brings together for the first time a comprehensive list of studies on each technique.

Free association must be recognized as one of the more disappointing
areas of research. It has yet to be effectively demonstrated just how
free association can be operationalized to increase creativity.

Each of the remaining techniques has received too little attention
to make any conclusive statements about them. Tentatively, however,
morphology and analogy both appear to have some promise. Forward-
backward problem-solving has yet to be tested as a creativity stimulation
technique. Incubation requires further conceptual refinement before
additional studies should be undertaken but it would apparently merit
that attention. Finally and very surprisingly, modelling has proven
ineffective in three relatively convincing tests of the technique.

In the future it would be hoped that:

1) better ways will be found to operationalize techniques.
2) some attention will be directed to determining the appropriate
   applications (i.e. problem types) for each technique.
3) ways will be found for synthesizing and combining techniques
to maximally increase the power of creative problem-solvers.
Chapter 3. A Design and Methodology for Testing C.S.T.'s

The focus of this thesis is an experiment which was contrived to test the relative effectiveness of several different creativity stimulation techniques. It is usually desirable in the case of experimental research to state one's hypotheses at the outset. In the case of the present research, however, one is not predicting which techniques will be superior to which others but rather attempting to effectively operationalize the techniques so as to determine how they would statistically compare with a control condition and a brainstorming benchmark condition. Therefore no hypotheses can be meaningfully stated.

In the course of designing this experiment many methodological issues had to be resolved. The research design had to be chosen. Both technique inductions and problem tasks had to be precisely defined. Subjects had to be selected. Measurement instruments needed to be created. Moreover, many other procedural matters required decisions. These decisions were made with the aid of: (1) the theoretical conceptions developed in Chapter One; (2) the established procedures for testing C.S.T.'s which were uncovered in the review of the empirical literature of Chapter Two and; (3) a pilot study.

3.1 The Pilot Study

In order to determine whether the technique instructions and the problem descriptions were clear and understandable pilot tests were necessary. The pilot tests allowed for some determination to be made about the time necessary: (1) to read and understand the instructions and (2) to complete the problems. Finally the pilot testing allowed for modification of the questionnaire which was to form part of the research
design.

Ten pilot studies were run. The subjects were asked to speak their thoughts aloud. A written record was made of whatever they said. At the end of each test they were asked a number of probing open-ended questions about the experiment. The pilot studies can be summarized as follows:

1. analogy and morphology upon a snow object creation problem.
2. morphology upon Dunn's sales problem.
3. forward-backward problem-solving upon the tourist problem.
4. analogy upon a snow recreation equipment problem.
5. brainstorming upon a T.V. adaptation problem.
6. forward-backward problem-solving upon a recreation problem.
7. morphology upon a T.V. adaptation problem.
8. brainstorming and forward-backward problem-solving upon Maier's change-of-work-procedures problem.
9. analogy upon the Maier and Dunn problems.
10. morphology upon the Maier and Dunker problems.

An instructed analysis of the results was performed after each new protocol was collected and examined, allowing for many and diverse changes to be made in the experimental methodology.

3.2 The Research Design

It was decided that the research design should allow for comparison of five single treatment conditions and three combined conditions. This was considered to be an appropriate balance in the trade-off between number of treatments and the number of subjects per treatment given the temporal, monetary and financial limitations inherent in the research.
Two of the treatment conditions to be chosen were benchmark or comparison conditions against which the other treatments could be evaluated. A control treatment and a brainstorming treatment were adjudged appropriate benchmarks. Analogy, morphology and forward-backward problem-solving were all chosen to be tested singly and in combination with brainstorming. These three techniques were chosen because of their importance in the literature and because relatively little has been demonstrated regarding their respective performances under controlled conditions. These techniques were combined with brainstorming in an unprecedented manner to explore the possibilities of combining techniques for problem-solving.

An experimental research design was chosen as it allowed the determination of cause and effect. Two experiments were conducted rather than one only as required in the thesis proposal. Data proved to be more accessible than was originally anticipated so a second group of subjects was randomly assigned to conditions in order to increase the power and generalizability of the findings. The first experiment involved 96 subjects, 12 subjects under each of eight different treatment conditions. The second experiment utilized 60 more subjects; this time, with 12 subjects under each of only five conditions. Furthermore, including the second experiment allowed for data to be collected upon a third problem and thereby to potentially increase the external validity of the experiment (Campbell and Stanley, 1963).

The first experiment is graphically represented as follows:
As can be seen from the diagram six subjects (randomly assigned) were asked to solve the Dunker problem and then the Dunn problem in that order using the analogy technique and so on.

The second experiment contained only the first five treatment conditions and the Maier problem was substituted for the Dunn problem.

The design described herein tests more C.S.T.\'s in a single experiment than any single piece of empirical research to date.

3.3 Treatments - the C.S.T. instructions.

The research proposal required that four single techniques, three combined techniques and a control condition all be operationalized.

Attempts were made to keep the instructions clear, concise and complete.
3.3.1 The Control Condition

As much of the control condition instructions as possible were to be subsumed in the instructions used in the other C.S.T.'s instructions. The researcher thereby attempted to avoid control condition instructions which were inhibitory of creative responses such as may have been the case in certain other studies (e.g. Meadow, Parnes and Reese, 1959; Parloff and Handlon, 1964).

The instructions were intended to be neither inhibitory nor facilitative. Therefore subjects were enjoined to find answers which were jointly original and potentially practical; instructions which Manske and Davis (1968) found to have no effect upon creative problem-solving effectiveness.

Adjoined to the instructions to look for answers which were jointly original and practical were three steps to follow in the problem-solving process (nb. these three steps were also attached to the bottom of the task problem). These procedural instructions contained elements of brainstorming.* Therefore, it must be stated that the control treatment chosen here was stronger than that generally chosen by researchers.

The Control Instructions

Attempt to produce creative solutions to the problem which you are given. Look for answers which are both original and potentially practical.

1. After you receive the problem, generate as many good answers as possible for the problem.

2. Mark the most promising ideas with an asterisk(*).

3. Select one of the most promising ideas and develop it further.

* See page 3.
3.3.2 The Brainstorming Condition

The brainstorming instructions which were chosen herein are basically similar to most used in the empirical research studies reviewed in Chapter Two (e.g. Taylor, Berry and Block, 1958). The brainstorming instructions include three of the central non-group elements of the brainstorming technique.

1. Letting one's imagination go free when developing possible solutions.
2. Going for quantity of potential solutions.
3. Deferring judgement until the idea generation stage is completed.

The Brainstorming Instructions

WRITE YOUR IDEAS FREELY AND WITHOUT REGARD TO QUALITY.
GO FOR QUANTITY. THE WILDER THE IDEAS THE BETTER. LET YOURSELF GO. DON'T BE CRITICAL.
DEFER JUDGING YOUR IDEAS UNTIL YOU HAVE GENERATED A SUBSTANTIAL NUMBER OF POTENTIAL SOLUTIONS.

3.3.3 The Analogy Condition

Analogies compose the core of the synectics approach which is in itself a much more complex creative problem-solving technique than any of the C.S.T.'s reported here. In reality, synectics is a composite of different ideas and techniques for stimulating creativity.

Gordon's (1961) approach to utilizing analogies for creativity was considered operationable and an attempt was made herein to succinctly and accurately describe three of his four types of analogies in a way that they could be easily utilized. Moreover, it was suggested that the subjects employ the analogies to accomplish the two different functions advocated
by Gordon, namely; (1) to make the strange familiar and (2) to make
the familiar strange.

The Analogy Instructions

An analogy is a partial similarity between two objects or processes. For example, "the heart is like a pump" and "governing a state is like
captaining a ship" are both analogies. Both of these analogies can be
extended so as to increase one's knowledge of the heart or of government.

When people are faced with a strange problem they often unknowingly
use analogies when reformulating the problem in more familiar terms. One
can use analogies also to make what is initially too familiar, strange,
and thereby obtain another slant on a problem.

There are three ways in which you can use analogies to help you
solve problems.

i) Direct Analogy

Look for 'direct analogies' to the problem whether from within
your realm of experience or from your imagination. Use objective
and impersonal images to describe the problem.

Hint: practice completing the following sentences:

1) "This problem is like ... (other problem of your experience or
imagination)...

2) "This object or process (in problem) is like ............
(some other object or process)".

ii) Personal Analogy

Think of yourself as being within the problem as different
inanimate objects or persons contained in it. Explore your way through
the problem in this way.
For example, a creative chemist might think of himself as a molecule permitting himself to be pushed and pulled by molecular forces.

iii) Fantasy Analogy
Ask yourself how in your wildest fantasies you might have the problem solved. 'Fantasy Analogy' is quite simply the child's game of "let's pretend", conjuring up the ideal solution to the problem, pretending it will work, and then seeing if you can find a way to make it work roughly as you had imagined.

Use each of these three methods in turn to aid you in your problem-solving.

3.3.4 The Forward-Backward Condition
Although forward-backward problem-solving is mentioned by people such as Polya in a mathematical problem-solving context; it is a technique which has not been operationalized for application in an experimental context or even suggested for usage with practical problems. Dr. Ken MacCrimmon suggested that this technique be applied in this experiment.
The resulting technique represents this researcher's conception of how such a technique might be meaningfully operationalized.

The Forward-Backward Instructions
Think of a problem as having two states, its initial state (I) and its final state (F).

Diagram

<table>
<thead>
<tr>
<th>Initial State</th>
<th>(I)</th>
<th>Forward problem-solving</th>
<th>backward problem-solving</th>
<th>Final State</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Where you are now)</td>
<td></td>
<td></td>
<td></td>
<td>(The point you wish to reach)</td>
</tr>
</tbody>
</table>
If one starts with an analysis of whatever information he possesses on the problem and works toward a solution he is involved in forward problem-solving.

If, on the other hand, one begins with a description of the solution he wishes to reach (the final state) and works backwards to the information he possesses he is involved in backward problem-solving.

Steps to follow:

I Forward Problem-Solving

1. Bring together whatever information you have on the problem both from the problem description and from your own memory.
2. Reformulate the problem in terms of your enlarged knowledge.
3. Attempt to provide solutions to the problem.
   - after spending some time exhausting possibilities with Forward problem-solving, write down possible answers.

II Backward Problem-Solving

1. Describe the characteristics of a good final state to this problem - you might even imagine ideal final states. Formulate some possible alternatives.
2. Now work backward to see what would have to be true for these final states to be possible.
3. Write down solutions which might occur to you.

3.3.5 The Morphology Condition

Zwicky popularized the morphology technique in the 40's and intended it to "identify, index, count, and parameterize the collection of all possible devices to achieve a specified functional capability" (Wills, p.135). In
order to adapt the technique to problems which didn't necessarily require
an invention as the solution, the instructions listed below were created.
The concepts 'solution-space' and 'multi-variable concept' were specifically
selected to help explain the technique to a naive subject. The morphological
scheme described below was utilized as an easier way of generating dimensions
and values than the standard matrix format favored by other writers (e.g. Wills).

The Morphology Instructions

For any problem, there exists a set of possible answers. This set
of possibly appropriate answers is called a SOLUTIONS SPACE. A description
of the solution space will describe the characteristics of any answer to
the problem.

If our problem is to design a dress, then the solution space contains
the set of all possible dresses. If we were to describe the solution
space we would have to describe dresses, in general.

Morphology is a technique which requires you to describe the solution
space in terms of its basic dimensions. For example, the basic dimensions
of a dress might be: (1) color, (2) fabric, (3) function, etc.

When one uses the morphology technique he arranges the dimensions
in a horizontal array as follows and adds key values under each dimension

<table>
<thead>
<tr>
<th>Dimension 1</th>
<th>Dimension 2</th>
<th>Dimension 3</th>
<th>etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>black</td>
<td>cotton</td>
<td>formal wear</td>
<td></td>
</tr>
<tr>
<td>Value 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>blue</td>
<td>linen</td>
<td>informal evening</td>
<td></td>
</tr>
<tr>
<td>Value 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>green</td>
<td>rayon</td>
<td>wear</td>
<td></td>
</tr>
<tr>
<td>Value 4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>red</td>
<td>wool</td>
<td>casual wear</td>
<td></td>
</tr>
<tr>
<td>etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>orange</td>
<td>etc.</td>
<td>sports wear</td>
<td></td>
</tr>
<tr>
<td>yellow</td>
<td></td>
<td>etc.</td>
<td></td>
</tr>
<tr>
<td>white</td>
<td></td>
<td>etc.</td>
<td></td>
</tr>
</tbody>
</table>
To use this morphological scheme in creative problem-solving, follow the directions below:

1. Take one value from under each dimension and combine into a 'multi-variable concept', e.g. a black, cotton, evening wear clothing design. (With this particular scheme two or more values could be drawn from each dimension, e.g. black and blue, wool and cotton, casual wear design).

2. Look constructively at the multivariable concept obtained, thinking how such an idea might be made feasible. Adapt this new idea as is necessary.

Therefore to use morphology:

1. Describe the set of all possible solutions in terms of a few basic dimensions.
   Hint: ask yourself what characteristics any answer to the problem must have.

2. Place important values on each dimension chosen and set up the morphological scheme as follows:

   Dimension 1 -------------- Dimension 2 --------------
   (name) value 1 value 2 value 3
   value 1
   value 2
   value 3

3. Create 'multi-variable concepts' by drawing a value from under each dimension.

4. Think about each 'multi-variable' concept constructively and adapt it as you see fit.
3.3.6 The Combined Techniques - The instructions for the combined techniques were to place brainstorming instructions immediately prior to the instructions of a second technique (See Appendix A, p. 151)

The three technique combinations which were chosen were:

1. brainstorming and analogy,
2. brainstorming and forward-backward problem-solving,
and 3. brainstorming and morphology.

The technique combinations always included brainstorming as any other two combinations of techniques would have been too difficult for a naive subject to easily grasp.

In conclusion, then:

1. The control instructions were completely subsumed within the instructions given to all subjects.
2. The brainstorming instructions were fairly standard.
3. Instructions upon the use of analogy, morphology and forward-backward problem-solving were specially created for this experiment as very little information is presently available on how best to operationalize these techniques.

3.4 Tasks - Problems

It was initially desired that the problems selected would be 'realistic' management problems for which relatively complete solutions could be generated. Moreover, it was imperative that more than one 'correct' answer was possible. It was further required that problem solutions were subject to fairly reliable rating scales which possessed a reasonable amount of face validity. Finally the problems had to be of a difficulty level which would produce some variance upon the dependent variable. If they were too easy almost everyone would provide good solutions and if too
difficult very few would produce even reasonable solutions.

The Dunn Sales Problem (Dunn, '68) is used for the first time in this research as a creative problem task. It has the advantage of being a realistic management problem requiring the creation of a new elaborated program. A special rating scale had to be constructed to evaluate solutions to this problem. The Dunn Sales problem is replicated below:

Bill Knowland has been a salesman for the United Steel Form Company for five years. The company sells standard and special forms to the construction industry. One of Bill's important customers is the Gerry Construction Company, a large general contracting firm that builds offices, plants and public buildings.

During a recent call on Gerry's purchasing agent, Bill hears that the company has won the bid for construction of a new aircraft component plant to be built in his territory. The purchasing agent tells him that his immediate concern is arranging for a reliable supply of a certain steel support form for the shell of the plant. United and all of its competitors manufacture this form to standard specifications. In effect, the P. A. warns Bill that he will soon be asking all suppliers for a price on this form, and that the order will be a large one.

After the call, Bill begins to study the problem. His company has recently raised the price on this item, and this is the first time he has had a problem working with the new price. One large competitor has followed the price rise, but the rest of the industry has not. In addition, Bill knows that the item
is standard throughout the industry and that his company as well as most of its competitors can make delivery on time and in the required quantities. United has a firm policy under which all customers are charged the same price for each item on the line.

As he considers his problem, Bill wonders, "How in hell do you sell a standard item to an important customer in large amounts without any product or service advantages and at a price above some of your competitors?" Salesman Bill Knowland is in need of a good, creative solution to his sales problem! What steps might Bill take to solve this problem?

The second problem, Maier's Change of Work Procedures Problem, has been used before in creative problem-solving research. It too, constitutes a realistic management problem but only requires an elaborated adaptation on an existing process. Two different rating scales are in use in the literature. One of them was refined for the purposes of this experiment. The Maier Change of Work Procedures Problem is described below:

In a large firm which manufactures communications equipment, a four man department has the responsibility for the entire production of a particular component. Three of the men perform the assembly work and the fourth acts as foreman. The assembly operation is divided into three positions and the workers have adopted a system of hourly rotation among the three jobs. The three jobs are not entirely routine and require somewhat different skills. However, all three of the men have been able to master each of the jobs at least minimally well, but still perform
some jobs better than others.

The foreman has called a meeting to discuss the possibility of their changing their work method to one where each man works only one position. This would be his best position according to the time study data given to the foreman. Although the new method should increase the productivity of the workers and thus their piece rate wages, the foreman's suggestion of a change to the new method was met with some resistance. The employees were concerned about the amount of boredom resulting from working at the same job all the time and believed that this might actually lower production. They were also a bit suspicious of management's motives in suggesting the new work method. Can you suggest a solution to the problem faced by the foreman and his crew?

The third problem, Dunker's Tumor Problem, is fairly well known to researchers in creativity. This problem does not possess the characteristic of being a realistic management problem but it does have the desirable characteristic of being easily scaleable. This problem requires the creation of a new process idea. Dunker's problem is described as follows:

By what procedures might one get rid of an inoperable stomach tumor without destroying the healthy body tissue if:

1. there are rays which will destroy organic tissue at sufficient intensity whether the tissue is healthy or tumorous.

2. the rays can be modulated in intensity.

Attached to every problem was a set of procedural instructions suggesting the steps one should follow in solving each problem. The instructions were
typed below every problem as follows:

1. Utilize technique instructions to aid you in finding possible solutions to the problem. Write your answers on the general answer sheet required. AT THIS STAGE GO FOR QUANTITY OF IDEAS.

2. Mark those ideas which are most promising with asterisks (*), i.e. those ideas which are both at least somewhat original and somewhat feasible.

3. Select the idea or combination of ideas which you consider to be the most creative. Develop your selection more fully on the proposal form. AT THIS STAGE WORK TOWARDS QUALITY.

These above instructions were presented to all subjects including those utilizing control instructions. Implicit within the above problem-solving procedure are the following ideas: (1) ideation is separated from judgment, (2) elaboration is added as a separate last step, and (3) quantity is emphasized at one stage and quality at another. In conclusion the control treatment is a strong technique in its own right and for another technique to be regarded as effective it must prove itself superior to the control technique.

3.5 Measurement - Rating Scales and Procedures

Three sets of rating scales had to be constructed to allow evaluation of the 'creativity' of the solutions to the three problems.

For Dunn's sales problem the elaborated answer was evaluated in terms of base points and bonus points. The base points options included the following:
Rating Scale - Dunn's Sales Problem

0 pts - Doing nothing

0-5 pts - for an argument for sale on the basis of past service
- for an argument for sale on basis of future service

10 pts - for attempting a direct price change
or for
attempting a direct product change (including a specification
of how this would be accomplished)

20 pts - for attempting an indirect price change
or
for attempting an indirect product change

Bonus points were given for:

1. direct influence attempts upon the purchasing agent - -5 to +5 pts.
2. for indirect influence attempts upon P. A. - 0 to 10 pts.
3. for each good idea on how an indirect price or product change might be accomplished - 4 pts each.
4. for suggesting both an indirect price and an indirect product change - 5 pts.
5. for utilizing a hierarchy or response format - 0 to 5 pts.
6. for suggesting a problem-solving approach wherein the salesman was first to research needs and then to fix incentives in terms of needs - 0 to 10 pts.

The rating scheme allowed some room for rater judgement on the quality of different ideas. A number of points was allowed for an aspect of an answer not covered in the rating scale. The answer would be allowed a base score of only 0, 5, 10, or 20 points. No combinations were allowed. Bonus points were then added (without upward limit) to the base score.

The rating scale for Maier's Change of Work Procedures Problem was a marginally adapted version of a scale proposed and employed by Campbell ('68).
Campbell found interscorer correlations of .73 and .96 (averaging .82) with the scale:

Rating Scale (for Maier's Change of Work Process Problems)

scale range 0 - 60 pts.

0 pts. - doing nothing

5 pts. - accepting management's new method without benefit of experimental tryout or group discussion of pros and cons.

20 pts. - equal time rotation for two best jobs but for periods longer than 1 hour.

35 pts. - some representative alternative between these two extremes: rotating between the two most suitable jobs and spending more time on the more suitable.

60 pts. - (a) ranking jobs for each person in terms of how well he can perform each one;
(b) having each person rotate among the three jobs such that he spends most of his time on his best job;
(c) carefully discussing the advantages and disadvantages of the new method in a group meeting with full opportunity for the employees to air their fears;
(d) providing for the experimental tryout of various rotation schedules so that the employees and foreman will be better equipped to choose the best one; and
(e) discussing the possibility of setting some production goals to strive for during the transition period.

At all steps along the scale extra points are to be given for adopting an experimental outlook with regard to various elements in the solution, providing for maximum two-way communication production goals in consulta-
tion with the employees.

The rating scale for the Dunker Tumor Problem was specially constructed for this research because it was realized that a right-wrong scale was inadequate to properly evaluate the solution ideas available. The various solutions were arranged in a hierarchy. The more feasible the solution, the higher the number of points given by the rater. Lower rated solutions require additional assumptions to be considered feasible.

**Rating Scale (for Dunkers Tumor Problem)**

7 pts. - Rotation Solution - either rotate the ray about the patient or the patient about the ray, maintaining the ray upon the tumor all the while

![Diagram of Rotation Solution](image)

P = person
RG = ray gun
\( = \) rays

6 pts. - Multiple Rays Solution - use rays each of less than critical intensities to converge upon tumor from different angles.

![Diagram of Multiple Rays Solution](image)

5 pts. - Focusing Solution - rays are focused so that their maximum intensity is at the point of the tumor.

![Diagram of Focusing Solution](image)

- OR -
- Pulsing Solution (using ray waves) - 2 or more rays are undulated so as to combine only at the point of the tumor.

4 pts. - Operate to Expose and Shield Solution - person is opened up so that the ray can be aimed directly at the tumor - surrounding tissue is somehow shielded from ray.

3 pts. - Operate to Expose (not shield).

2 pts. - Chemical Solution - sensitize tumor to ray with special chemical placed in tumor (or alternatively desensitize surrounding tissue).

1 pt. - Miniaturizing ray gun or channeling rays through tubing. 1 extra point if solution contains method for protecting surrounding tissue.

Where the answer given is subject to multiple interpretations and the solution is generally poorly explained, give half marks.

When more than one answer is given - grade the highest quality answer.

The two raters were chosen to evaluate each problem. The author participated as one of the raters for evaluating each set of problem solutions as his academic background and problem familiarity inclines him fairly well to judge the adequacy of both the Sales Problem solutions and the 'Change of Work Procedures' problem solutions. The second rater for the sales
problem was PhD student in Marketing and the second rater for the Change of Work Procedures problem was a PhD Student student in Organizational Behavior. The scale for the Dunker problem left little room for judgement so the qualifications of the raters was unimportant. For this task a PhD candidate in Sociology helped rate the solutions.

Prior to rating the solutions each rater and the author spent about an hour in discussion regarding interpreting the scales.

After the ratings were independently completed, the judges either averaged the results when differences were marginal or re-evaluated them when differences were greater. The resulting scores constituted the experimental dependent variable. Where adjudication took place there was usually fairly good agreement upon the final answer. Some of the times discrepancies resulted from a misreading of answers, in other cases from genuine ambiguities in the subjects response.

The raters were financially compensated for their time spent judging solutions and for adjudicating upon discrepent results.

3.6 The Questionnaire

A two part questionnaire was constructed to collect attitudinal information. Solution quality is either directly or indirectly related to a number of factors other than by the application of a specific C.S.T. Questions were constructed to measure some of these potential factors:

(a) attitudes towards the techniques (8 questions)
(b) mode of technique employment (5 questions)
(c) attitudes towards the problems (7 questions)
(d) attitudes towards the solution (5 questions)
(e) attitudes towards himself (3 questions)
The first part of the questionnaire was completed after problem one and the second part, after problem two.

3.7 The Subjects

Because the research was designed to demonstrate the relative effectiveness of various C.S.T.'s in the hands of people with average and above intelligence, students were felt to be appropriate subjects for such research. Moreover, since the C.S.T.'s were being tested on business problems, commerce students were selected. In order to minimize variance in subject knowledge levels, subjects were taken entirely from second year Commerce at the University of British Columbia.

The subjects were generally 20-25 years old, and generally Caucasian males (approximately 10% females and 10% orientals). It would also be expected that a very high percentage of the students would have been Canadian citizens.

3.8 Methods and Procedures

Other factors which are important to the functioning of the experiment include: verbal instructions given subjects, timing of the various stages in the experiment, subject motivation, and the setting in which the experiment took place.

First of all the subjects were told that the experiment in which they were about to participate was an exercise in creative problem-solving. It would take about an hour and twenty minutes. Those who performed well would win monetary prizes. The system of rewards was then explained.

The motivation was in the form of $200.00 payment for high quality answers to questions. One, twenty-five dollar prize. Ten, ten dollar prizes. Ten, five dollar prizes and finally twenty-five, one dollar prizes. It was
made very clear that these awards were to be made to the people producing the highest quality answers.

The material they were to need was presented in a folder. They were asked to verify if they had the requisite number of pages of various colors. The materials included:

a) technique instructions (blue paper)
b) 2 problems (1st on yellow paper and 2nd on gold paper)
c) 2 types of answer sheets and scrap paper (all on white paper)
   i) general answer sheets
   ii) selected problem answer sheet
d) 2 questionnaires (one on pink and the other on green paper)

The procedures to be followed by the subjects was explained as follows:

1. They would have seven minutes to read and digest the problem-solving instructions. They were to use the instructions to help them find good solutions to the problem.

2. They next were to read the first problem and the problem instructions at the bottom of the page. They were to use the problem-solving instructions to aid them in the next thirty minute problem-solving activity.

3. After completing the problem they were to fill out the first questionnaire. (Approx. seven minutes - until the whole group completed the exercise.)

4. The group were then told to read the second problem and commence problem-solving, this time attempting to utilize their technique instructions more effectively.

5. At the completion of the second thirty minute problem-solving exercise the subjects were told to finish the second questionnaire on their own
The time required for each of the above steps was written on the board in abbreviated form (i.e. 1st problem - 30 minutes). The time left during a problem-solving activity was continuously being posted on the board for all to see.

In addition to the above instructions the subjects were asked to reveal if they were familiar with either of the two problems which they were asked to solve. One subject admitted seeing a problem before. Three or four others started the exercise but did not finish. The results of these subjects were deleted and replacement subjects were used in their stead.

Furthermore, on five separate occasions during the experiment the subjects received various reminders. After ten minutes work on each problem the subject was told, "Do not forget to use the technique instructions on the blue sheet as aids in problem-solving." After fifteen minutes work on each problem the subject was told, "Do not forget to complete all the requests on the problem sheet." The fifth interruption was between the two problem-solving sessions. The subjects were told that upon finishing the questionnaire they were to think of mistakes they had made in using the techniques and think of ways to use them more effectively on the second problem.

At the end of the session the subjects were very politely but convincingly asked not to talk about the experiment with their friends for a couple of weeks.

All of the data were collected in seven classroom sessions over a period of one week.
3.9 Discussion of Methodological Innovations

This experiment contains within it several innovations in methodology. The experiment was designed to test the relative effectiveness of several creativity stimulation techniques and technique combinations. Some of the techniques were operationalized for the first time in the manner they were found in the experiment. New problems were chosen for tasks. Subjects were requested to utilize a prescribed problem-solving format. Moreover, the measures of creativity were taken upon a single elaborated solution proposal that the subjects developed for each of the two problems he was given. Finally, subjects were asked a number of questions relating to the problem-solving situation via two questionnaires - one administered half-way through testing and the other, at the completion of testing.

There are only a few existing studies which are designed to test the comparative effectiveness of two or more different creativity stimulation techniques. In fact, this study is the first to test so many different techniques at the same time.

Furthermore, this research constitutes the first test of forward-backward problem-solving as a creatively stimulation technique. Analogy was operationalized for the first time as a multifaceted creativity stimulation technique. In effect, the analogy instructions contained many aspects of synectics (W. J. J. Gordon, 1961). What is more, morphology users were asked to dimensionalize the "solution space" of the problem and to develop "multi-variable concepts". Therefore morphology also contained innovative elements. Furthermore the three techniques described above were combined with brainstorming and experimentation with combined techniques is still in a very formative state.

In addition, this experiment utilized two 'benchmarks', by which to judge the relative effectiveness of other techniques. The first
benchmark was a strong control condition. In the control condition the subjects were in effect asked to attempt to produce creative solutions by utilizing a three stage problem-solving sequence - alternative generation, judgement and elaboration. It was suggested that the subject aim for quantity in the alternative generation stage and for quality in the elaboration stage. In effect the control condition might be thought of as a weak brainstorming treatment. In the brainstorming treatment the subjects were further requested to 'let their imaginations go'. Moreover, the brainstorming treatment stressed the various aspects of brainstorming to a greater degree than did the control treatment.

One of the three problems was used for the first time herein as a measure of creative attainment. Dunn's sales problem was selected and a rating scale specially designed. This problem appears to be a fairly realistic measure of creative organizational problem-solving. Maier's "change of work process" problem was also used because of its realism as a measure of organizational business creativity. The third problem, Dunker's tumor problem, was chosen because of the high face validity inherent in the scaling procedure. The more realistic problems presented more of a scaling challenge which is reflected in lower interrater reliabilities.

The requirement that all subjects (no matter what treatment condition) follow a prescribed problem-solving format is unique to this research. The subjects were given twenty minutes (approximately) in which to develop good ideas for the solution. In the last ten minutes they were to judge among these ideas and to elaborate one or a combination of them into a written solution. This guidance was given in order to provide answers of comparable length and complexity for all treatments. The reason for requiring elaborated solutions was so as to increase the realism of the ex-
exercise. A manager will most likely be asked to develop only few elaborated proposals (most often one) for organizational projects. Moreover, the development of an idea often requires as much creativity as did its initial conceptualization.

Furthermore, questionnaires were designed to ferret out the opinions of subjects upon the techniques, the problems, and upon various other aspects of the problem-solving situation. The use of attitudinal information as an aid to analysis of C.S.T. effectiveness is also in a formative stage.
Chapter 4 The Presentation and Discussion of Results

The results of the experiment described in chapter three are presented below in four parts. The results are accompanied by an appropriate discussion of findings. The first part of the chapter contains an analysis of answer ratings by problems, techniques and order of problem presentation. This analysis involves only descriptive or nonparametric statistics. In part two the ratings are analyzed by the A.N.O.V.A. technique - a parametric statistical technique. In part three the questionnaire data are introduced. The number of questionnaire variables were reduced with the aid of factor analysis for the sake of scientific parsimony. The new indexed variables (composites of the questionnaire variables) are utilized to describe the techniques and to analyze their respective effectiveness under varying conditions (e.g. moderator analysis). Finally in part four the questionnaire data are utilized to eliminate alternative explanations for the findings of the other three parts. For this purpose, a multiple regression analysis is employed upon the ratings using the questionnaire data as potential predictor variables.

The above format for data presentation is intended as a resolution to a problem which all data analysts face. On the one hand, the more assumptions a data analyst is willing to make, the more information he may be able to generate. But, on the other hand, the more assumptions he makes, the less confident he can be about his information.* Therefore, if one is unwilling to make assumptions he will end up information poor, whereas if one makes many assumptions he will end up with poor information.

*N.B. Information that is based upon a greater number of assumptions is subject to a greater number of alternative explanations. Hence the reduction of confidence.
Instead of erecting the current findings upon a single set of assumptions it was deemed superior to proceed by stages - each subsequent stage requiring more assumptions than its predecessor. As a result, the riskier findings are found in the latter parts of this chapter.

4.1 The Ratings - A Description and Initial Analysis

Currently, research methodology is characterized by an over-reliance upon sophisticated statistical techniques. By ignoring the simpler forms of analysis the researcher runs the risk of missing the forest for the trees. This section of the chapter is intended to paint the findings in broad relief.

The first table in this chapter illustrates the distribution of ratings obtained upon answers to the Dunker tumor problem. The horizontal axis of figure 4.1 (see following page) provides the range of scores attainable while the vertical axis provides the number of individuals obtaining each score. The figure contains the grand mean and standard deviation for all subjects and the range of mean scores for the C.S.T.'s in addition to the distribution of subjects across ratings. One should note the high proportion of zero scores which accounts for the left skewed distribution. Moreover, it is also significant that the range of technique means is so restricted (2/7ths of the scale range).

Figure 4.2 illustrates the frequency distribution of rating scores upon the Dunn sales problem. In this case the distribution more closely approximates a normal curve. Furthermore, the range of technique means is less constricted than in the case of the Dunker problem (1/3 of scale range).
Figure 4.1
Distribution of Averaged or Adjudicated Ratings on the Dunken Tumor Problem
(156 Observations)

Mean = 1.26
Standard Deviation = 1.93
Figure 4.2
Distribution of Averaged or Adjudicated Ratings on the Dunn Sales Problem

(96 Observations)

Mean = 21.04
S.D. = 12.2
Figure 4.3 illustrates the distribution of ratings obtained upon the Maier change-of-work procedures problem. This problem also generated a high percentage of zero rated answers (20 of 60) and the resulting left skewed distribution. In this case the range of technique means is very constricted (1/9th of scale range).

The distribution of scores on the three problems illustrates the difficulty of demonstrating technique superiority diagramatically. The following table presents the means and standard deviations of technique scores by problem.

| Table 4.1 The Means and Standard Deviations of Ratings by Techniques and Problems |
|---------------------------------|-----------------|-----------------|-----------------|
|                                  | Dunker Problem  | Dunn Problem    | Maier Problem   |
|                                  | (N= 156)        | (N= 96)         | (N= 60)         |
| benchmark                       |                 |                 |                 |
| treatments                      |                 |                 |                 |
| Control                         | M=1.2 (S.D.=1.8)| 20.6 (12.5)     | 10.1 (9.4)      |
| Brainstorming                   | 1.8 (2.5)       | 25.4 (12.7)     | 10.6 (13.9)     |
| treatments                      |                 |                 |                 |
| Analogy                         | 1.2 (2.0)       | 9.0 (10.3)      | 8.0 (9.7)       |
| C.S.T. Forward-Backward         | 1.1 (1.7)       | 19.9 (8.9)      | 10.9 (9.4)      |
| Morphology                      | .3 (1.1)        | 27.4 (16.3)     | 5.3 (5.9)       |
| treatments                      |                 |                 |                 |
| B-S § Analogy                   | 1.6 (1.9)       | 25.5 (11.0)     | ---             |
| C.S.T. B-S § F-B                | 2.3 (2.2)       | 21.7 (8.4)      | ---             |
| treatments B-S § Morphology     | 1.5 (2.3)       | 19.6 (9.2)      | ---             |

Table 4.1 above lends itself to a number of interesting observations. Firstly, the means of the combined techniques approximated the brainstorming score on both problems of experiment one.* This is interesting in that brainstorming composed the first of the two treatments to which each subject in the combined treatment was exposed. Secondly, the mean scores resulting

---

* Combined techniques' scores averaged 1.8 and 22.3 while brainstorming averaged 1.8 and 24.5 respectively.
Number of Subjects

![Graph showing distribution of ratings on problem procedure problem with mean and standard deviation values]

Figure 4.3
Distribution of Averaged or Adjudicated Ratings on the Major three of Work Procedures Problem
(50 Observations)

Mean = 5.98
Standard Deviation = 9.9

Scores on Problem
from the forward-backward condition approximated that achieved by the control condition on all three problems. Finally, the morphology treatment proved to be strongly interactive with the problems producing the poorest results twice and the best results once.

The order in which the two problem tasks were presented the subject is also of interest as is illustrated in Table 4.2 below.

<table>
<thead>
<tr>
<th></th>
<th>Dunker Problem (N=156)</th>
<th>Dunn Problem (N=96)</th>
<th>Maier Problem (N=60)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>When problem is first</strong></td>
<td>1.5 (2.0)</td>
<td>22.2 (13.7)</td>
<td>9.9 (10.7)</td>
</tr>
<tr>
<td><strong>When problem is second</strong></td>
<td>1.0 (1.8)</td>
<td>19.9 (10.6)</td>
<td>7.9 (8.9)</td>
</tr>
</tbody>
</table>

In the case of all three problems, subjects averaged higher scores on the first of the two problems which they were asked to solve.* Therefore order of problem presentation appears to be another factor accounting for ratings variance among subjects.

Problems, techniques and order of problem presentation, therefore, all represent accountable sources of variance. Alternatively, what sources of error variance might be expected in this research? Rating errors are a first possible source of error. To the degree that there is agreement between independent raters on the scoring of answers, then the ratings are said to possess high inter-rater reliability. Otherwise the ratings contain a high degree of error variance. Tables 4.3 presents not only the inter-rater reliabilities between the two independent raters but also the inter-correlation between the judges ratings and the final averaged and/or

*Differences were statistically significant at .001, .001 and .1 respectively.
adjudicated scores (A ratings). These A ratings represent the consensus of the judges on a second reading of answers which had previously lead to discrepant judgements.

TABLE 4.3 The Inter-rater Reliabilities on Problem Ratings

**Dunker problem**
(N=156)

<table>
<thead>
<tr>
<th></th>
<th>1st Set Ratings</th>
<th>Adjudicated Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rater 1 mean</td>
<td>1.34</td>
<td></td>
</tr>
<tr>
<td>Rater 2 mean</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>Adjudicated mean</td>
<td>1.26</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2nd Set Ratings</th>
<th>Adjudicated Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.83</td>
<td>.92</td>
</tr>
</tbody>
</table>

**Dunn Problem**
(N=96)

<table>
<thead>
<tr>
<th></th>
<th>1st Set Ratings</th>
<th>Adjudicated Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rater 1 mean</td>
<td>17.00</td>
<td></td>
</tr>
<tr>
<td>Rater 2 mean</td>
<td>20.99</td>
<td></td>
</tr>
<tr>
<td>Adjudicated mean</td>
<td>21.04</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2nd Set Ratings</th>
<th>Adjudicated Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>.60</td>
<td>.81</td>
</tr>
</tbody>
</table>
Maier Problem
(N=60)

<table>
<thead>
<tr>
<th></th>
<th>1st Set Ratings</th>
<th>Adjudicated Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rater 1 mean = 6.1</td>
<td>X</td>
<td>.58</td>
</tr>
<tr>
<td>Rater 2 mean = 12.2</td>
<td>.40</td>
<td>.67</td>
</tr>
<tr>
<td>Adjudicated mean = 9.0</td>
<td>.40</td>
<td>.67</td>
</tr>
</tbody>
</table>

Where previous disagreements were inconsequential or where they persisted in the second evaluation scores where averaged. As a number of errors in coding were uncovered by one or the other rater in the re-evaluation process, initial inter-rater reliabilities may be thought of as lower bounds on the reliability of the ratings.

Table 4.2 reveals inter-rater reliabilities to be highest in the case of the Dunker tumor problem as was expected but much lower than expected in the Maier change-of-work processes problem, considering the previous findings of Campbell (1968) with the same scale.* In fact, in the Maier problem low inter-rater reliabilities must be thought of as major source of error variance.

Another source of error variance could be differences in subject abilities. If subjects' abilities where to be a major factor in determining answer quality, one would expect a relatively high correlation between the scores subjects obtained upon the first and second problem.

* Campbell found average inter-rater reliability with the scale to average at .82
* Ratings methodology is explained on pages 87 and 88.
The inter-correlation between subject scores in experiment one was .10 (p=.16), and in experiment two, it was -.05 (p=.36). These low inter-correlations suggest that subject ability differences do not account for a significant proportion of the error variance.

In Summary

a) The problems: Because of the large number of subjects who were unable to produce creative answers to the Dunker and the Maier problems, the variance on the dependent variable was unfortunately constricted. Another consequence of the high proportion of zero scores is a left skewed distribution which suggests the necessity of raw score transformation to precede parametric analysis. In addition to these difficulties, the Maier problem suffered from relatively low inter-rater reliabilities. Given the difficulties with the Dunker and Maier problems, it would appear that the Dunn problem proved most useful for the above analysis because of: its high degree of realism as an organizational problem; its allowance of elaborated answers; its acceptable inter-rater reliabilities; and its normally distributed set of answers.

b) The techniques: The ranges of technique performance scores is restricted, especially in the case of the Maier problem. As a result it would appear that either technique differences were not all that great or that stronger statistics are needed to highlight the differences that do exist. Moreover, the combined techniques were no more effective than brainstorming alone. Further, forward-backward approximates the control condition in effectiveness. And finally, morphology appears to interact with problems.
c) **The order of problem presentation:** It would appear that subjects perform more effectively with the first problem they encounter, perhaps suggesting a fatigue or frustration factor, and certainly not a practice or learning effect.

d) **Other findings:** One source of error variance includes the difficulty of rating answers, especially in the case of the Maier problem. Subject ability differences, on the other hand, probably did not account for an important source of error variance.

4.2 **Parametric Statistical Analysis**

A controversy has been raging in the literature between those statisticians favoring the use of non-parametric statistics and others favoring parametric statistics. In a current book of readings which addresses itself to this dispute the editors conclude:

> In summary, the main arguments advanced for the use of non-parametric methods in the place of parametric methods are not very compelling . . . even though the use of parametric methods requires more assumptions than non-parametric methods, failure to meet these assumptions does not appear to have serious consequences in most instances (Heerman and Braskamp, 1970, p. 37).

Given that the assumption of normally distributed data has been violated in the case of the Dunker and Maier data, it makes sense to minimize the deviation from normalcy by transforming the raw data. To this end the square roots of the raw scores were substituted for the subsequent analysis.

The first parametric test to be imposed upon the data was a one way analysis of variance. The F statistic was calculated to determine if the probability of between techniques effects was significant or not.
Firstly, in the case of the Dunker problem with all 156 subjects (Table 4.4), the between techniques effect was almost significant at the .05 level (n.b. p = .057) whereas with the Dunker problem on the first part of the experiment only (Table 4.5), the between techniques effect was significant beyond .05 (p = .032). Secondly, in the case of the Dunn problem (Table 4.6), the between technique treatments effects was significant at the .009 level of significance yielding a more substantial portion of between treatments variance for analysis. Finally, in the case of the Maier problem (Table 4.7), between technique difference was insignificant (p = .681).

A series of contrasts* were calculated to determine the significance of differences between the benchmark technique conditions and the other techniques. Tables 4.4 through 4.7 display the results of this analysis.

**TABLE 4.4**

Dunker problem (156 subjects from both experiments)

Square roots of raw ratings)

<table>
<thead>
<tr>
<th>Between groups significance</th>
<th>.057</th>
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Contrasts between techniques and standards

<table>
<thead>
<tr>
<th>Significance of difference</th>
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<tbody>
<tr>
<td>Control vs Analogy</td>
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<td>Control vs Forward-Backward</td>
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<tr>
<td>Control vs Morphology</td>
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<tr>
<td>Brainstorming vs Analogy</td>
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<td>Brainstorming vs Forward-Backward</td>
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<td>Brainstorming vs Morphology</td>
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Means of Group Scores - Roots of Raw Scores

<table>
<thead>
<tr>
<th>Morphology</th>
<th>Frwd-Bkwd</th>
<th>Control</th>
<th>Analogy</th>
<th>Brainstorming</th>
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<tr>
<td>.14</td>
<td>.60</td>
<td>.64</td>
<td>.67</td>
<td>.86</td>
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*The significance of differences in contrasts are calculated by means of a t-test.
not significantly different from the control condition at the
.05 level of significance.

not significantly different from the brainstorming condition at
the .05 level of significance.

**TABLE 4.5**

Dunker problem (96 subjects of the first experiment only;
Square roots of raw rating).

Between groups significance
- eight treatment groups .032

**Contrasts between techniques and standards**

<table>
<thead>
<tr>
<th>Significance of difference</th>
<th>.709</th>
<th>.076</th>
<th>.033</th>
<th>.787</th>
<th>.235</th>
<th>.022</th>
<th>.011</th>
<th>.417</th>
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<tr>
<td>Control vs Analogy</td>
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<td>Control vs Forward-Backward</td>
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<td>Control vs Morphology</td>
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<tr>
<td>Control vs Combined techniques</td>
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<td>Brainstorming vs Combined Techniques</td>
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**Means of Groups Scores - Roots of Raw Scores**

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not significantly different from the control condition at the
.05 level of significance.

not significantly different from the brainstorming condition at
the .05 level of significance.
TABLE 4.6

Dunn problem (raw ratings of 96 subjects).

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Contrasts of techniques with benchmark conditions

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Means of Group Scores. (Raw Ratings)

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not significantly different from control or brainstorming conditions.
TABLE 4.7

Maier problem (Square root scores with 60 subjects).

Between groups significance
- five groups \( .681 \)

Contrasts of techniques with benchmark conditions

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Means of Groups Scores (Square Roots of Ratings)

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not significantly different from control or brainstorming at the .05 level of significance.
The analysis of contrasts suggest that only the morphology condition is significantly inferior to both the control and brainstorming conditions on the Dunker problem. Forward-backward problem-solving proves to be significantly inferior to the control condition when both parts of the experiment are combined (N=156). On the Dunn problem only analogy proves significantly different to the benchmark conditions at the .05 level of significance. Finally, with the Maier problem no treatment conditions are significantly different from the benchmark conditions.

In Summary

In general, it could be concluded from the above analysis that either the performance of the C.S.T.'s are not very different from each other on each of the three problems or that the strength of the test of differences was not strong enough to demonstrate the relative effectiveness of the different techniques.

More specifically, one may conclude that each of the three single treatment conditions has proved significantly inferior to at least one benchmark condition on at least one problem. This may indicate: (1) that the techniques are interacting with the problems (e.g. morphology); or (2) the single techniques are somewhat generally inferior to brainstorming; and/or (3) that the relatively unresearched techniques were not operationalized as effectively as brainstorming. One is required to proceed to an analysis of questionnaire data to shed more light on these alternatives.
4.3 The Questionnaire Data: A Description of the Technique Inductions

The purpose of (data) analysis is to reduce data into intelligible and interpretable form so that the relations of research problems can be studied and interpreted. (Kerlinger, 1973, p. 134).

Forty-nine different questions* were asked of each subject during the experiment. Most questions were constructed to reveal the subject's attitudes towards the techniques, the problems and his solutions. The remaining questions asked about his problem solving process and various other items. It was decided to perform a factor analysis on the questionnaire for two different purposes: (1) to check the internal validity of the questionnaire as a whole and (2) to reduce, if possible, the number of distinct variables that one had to use in subsequent analyses. As the questionnaire was an ad hoc creation of the researcher,** it made sense to test the internal consistency of the instrument to find out how reliable it might be. Furthermore, the scientific principle of parsimony suggests that it makes more sense to use fewer variables, where feasible, in the place of many.

Factor analysis was chosen as a method of data reduction because it is a fairly well established multivariate technique in a period when the relative merits and demerits of various multivariate techniques is not well understood. Because the researcher was interested in using independent factors in the analysis, orthogonal extraction and rotation were chosen. The principle components method of extraction was used because it

*Sometimes more than one question was asked under a single number on the questionnaire.

**The questionnaire was constructed for purposes of exploratory research rather than for hypothesis testing.
extracts the maximum amount of variance attributable to each additional factor as it is extracted and as a result yields a unique solution. The varimax method of rotation was used as it maximizes the variance explained by the factor structure - a consequence which is compatible with the reduction objective. The results of the factor analysis are to be found on the next page (i.e. Table 4.8).

The variables in the vertical column of Table 4.8 were arranged in an order so as to facilitate interpretation. A key to code names used for variables is to be found on page 166 of the appendices. The factors are represented along the vertical axis in order of extractions. All factor loadings of .30 and higher are to be found in the cells of the matrix.

Given the very large number of low loadings, one does not have too much trouble determining which variables load on which factors. In effect, the factor analysis has clustered variables in very meaningful patterns which leads one to conclude that the questionnaire possesses a rather high degree of internal consistency.

Largely, on the basis of the clustering of variables by the factor analysis a list of new variables was constructed. Only two of the thirteen new variables had to be constructed more upon logical grounds than upon mathematical clustering. Firstly, an effort index variables was composed of the sum of reported effort upon problems one and two even though these two variables fell on different factors. (correlation between effort (1) and effort (2) = .31). And secondly, a generation index factor was composed separately despite the fact that these two variables were combined with elaboration on the same factor. (correlation between generation 1 and generation 2 = .54). Otherwise, factors were basically constructed as would be indicated by the factor analysis reported above.
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% of Variance

|            | 31.4 | 15.4 | 9.4  | 7.7  | 6.7  | 5.6  | 5.3  | 4.8  | 4.0  | 3.7  | 3.3  | 2.9  |

TABLE 4.8 Results of the Factor Analysis (Omitting all factor loading below 1.30)
Table 4.9  Index Variables Composed from Questionnaire Variables

1. **Index of Self-Rated Performance**
   \[ \begin{align*}
   & = \text{General Creativity (1) + Performance (1) + General Creativity (2)} \\
   & \quad + \text{Specific Creativity (1) + Confidence + Specific Creativity (2)} \\
   & \quad + \text{Performance (2)}
   \end{align*} \]

2. **Index of Technique Appreciation**
   \[ \begin{align*}
   & = \text{technique effectiveness (2) + improvement with technique (1) +} \\
   & \quad \text{Mastery of technique and enjoyment of technique + technique} \\
   & \quad \text{difficulty + interest in technique.}
   \end{align*} \]

3. **Index of Time**
   \[ = \text{Time on p. 1 + time on p. 2} \]

4. **Analysis Index**
   \[ = \text{analysis (1) + analysis (2)} \]

5. **Other Index**
   \[ = \text{other (1) + other (2)} \]

6. **Index of Understanding**
   \[ = \text{clarity + completeness} \]

7. **Index of Problem (1) Appreciation**
   \[ = \text{interest in p. (1) + enjoyment of p. (1) + realism of p. (1)} \]

8. **Elaboration Index**
   \[ = \text{elaboration (1) + elaboration (2)} \]

9. **Generation Index**
   \[ = \text{generation (1) + generation (2)} \]

10. **Index of Problem (2) Appreciation**
    \[ = \text{interest in p. (2) + enjoyment of p. (2) + realism of p. (2)} \]

11. **Effort Index**
    \[ = \text{effort on p. (1) + effort on p. (2)} \]
12. Evaluation Index

\[ \text{Evaluation Index} = \text{evaluation (1)} + \text{evaluation (2)} \]

13. Index of Problem Improvement

\[ \text{Index of Problem Improvement} = \text{improvement on p. 1 and effectiveness on p. 1} \]

The thirteen index variables listed above were utilized to further explain the problem-solving process elicited by the various C.S.T.'s. Subjects were asked to distribute the time spent problem-solving into proportions representing the approximate amount of time spent on each stage of the problem-solving process: (1) analysis, (2) alternative generation, (3) evaluation between alternatives, (4) solution elaboration, and (5) other. Table 4.10 lists the amount of time subjects spent on different stages of problem-solving by techniques.

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>Control</td>
<td>20.6%</td>
<td>38.6%</td>
<td>14.1%</td>
<td>25.0%</td>
<td>2.4%</td>
</tr>
<tr>
<td></td>
<td>14.8</td>
<td>39.4</td>
<td>14.4</td>
<td>23.8</td>
<td>5.3</td>
</tr>
<tr>
<td>Analogy</td>
<td>17.7</td>
<td>43.7</td>
<td>14.2</td>
<td>19.6</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td>15.7</td>
<td>39.4</td>
<td>8.2</td>
<td>22.4</td>
<td>4.8</td>
</tr>
<tr>
<td>Brain-storming</td>
<td>19.4</td>
<td>49.5</td>
<td>9.5</td>
<td>19.0</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>17.7</td>
<td>43.0</td>
<td>15.0</td>
<td>21.7</td>
<td>6.1</td>
</tr>
<tr>
<td>Forward-Backward</td>
<td>24.6</td>
<td>35.2</td>
<td>16.3</td>
<td>19.7</td>
<td>4.3</td>
</tr>
<tr>
<td></td>
<td>17.9</td>
<td>33.2</td>
<td>12.3</td>
<td>19.7</td>
<td>16.3</td>
</tr>
<tr>
<td>Morphology</td>
<td>27.4</td>
<td>34.7</td>
<td>17.5</td>
<td>16.4</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>22.0</td>
<td>34.6</td>
<td>14.5</td>
<td>22.0</td>
<td>5.2</td>
</tr>
<tr>
<td>Means</td>
<td>19.7%</td>
<td>39.7%</td>
<td>13.69%</td>
<td>21.0%</td>
<td>5.6%</td>
</tr>
</tbody>
</table>
Table 4.10 yields a few observations of significance to the present analysis:

1. About 60% of the subjects' time was spent upon "analysis" and "idea generation" and about 35% of their time was spent upon "evaluation" and "elaboration." It was suggested in the problem instructions that subjects divide this time, 66 2/3% to 33 1/3% of the total time available. It can then probably be concluded that the subject followed the experimental instructions.

2. The subjects claim to have spent the bulk of their time (approx. 95%) in active problem-solving which increases the likelihood that they took the exercise seriously. Moreover, the fact that subjects could classify the overwhelming proportion of their time into the four problem-solving stages illustrates the usefulness of the models.

3. Brainstorming emphasizes "idea generation" more than the other techniques as would be expected from instructions which stress finding as many potential solutions as possible.

4. Morphology emphasizes "analysis" more than the other techniques as would be expected from instructions stressing the dimensionalization of the solution space.

5. Control subjects spent more time upon elaboration than the other technique users and less time than all groups with the exception of forward-backward upon analysis and generation combined. It might therefore be expected that techniques would tend to reduce the solution orientation exhibited by most problem-solvers (Maier and Solem, 1962).

The above analysis describes the various techniques by the manner in which they affected the decision-making process. The following analysis describes the techniques in terms of other relevant questionnaire variables.
TABLE 4.11 Techniques as Described by Selected Questionnaire Variables

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Time using technique</td>
<td>35.6 min.</td>
<td>36.1 min.</td>
<td>35.0 min.</td>
<td>30.3 min.</td>
<td>33.1 min.</td>
<td>28.5 min.</td>
<td>30.3 min.</td>
</tr>
<tr>
<td>2. Effort on Task</td>
<td>7.8</td>
<td>7.1</td>
<td>6.5</td>
<td>6.6</td>
<td>7.3</td>
<td>7.3</td>
<td>7.3</td>
</tr>
<tr>
<td>3. Technique Understanding</td>
<td>7.5</td>
<td>8.9</td>
<td>6.8</td>
<td>7.0</td>
<td>8.0</td>
<td>7.3</td>
<td>8.0</td>
</tr>
<tr>
<td>4. Technique Appreciation</td>
<td>22.3</td>
<td>22.3</td>
<td>20.2</td>
<td>19.8</td>
<td>23.4</td>
<td>22.8</td>
<td>23.4</td>
</tr>
<tr>
<td>5. Self-Rated Performance</td>
<td>24.2</td>
<td>25.4</td>
<td>20.1</td>
<td>23.1</td>
<td>21.3</td>
<td>24.3</td>
<td>27.3</td>
</tr>
</tbody>
</table>

* Upper figure represents scores on Experiment one. Lower figure represents scores on Experiment two.

The main observations to be gleaned from Table 4.11 include the following:

1. Brainstorming S's are characterized as having the highest time utilizing the technique, the highest level of technique understanding, the highest level of technique appreciation, the second highest effort expenditure and the second highest self-evaluated performance of the single techniques.

2. Analogy S's are characterized as having the lowest effort on task, the lowest appreciation of the technique and the lowest self-evaluated performance in addition to the second lowest time spent using techniques and the second lowest level of understanding.
3. Forward-backward problem-solving S's are characterized as having the lowest amount of time using the technique, the lowest level of technique understanding, the second lowest "effort" on task and the second lowest technique appreciation but surprisingly the highest "self-evaluated" performance.

4. Control subjects had the highest effort on the task.

5. Morphology scored approximately the middle of the range on all five variables.

6. The brainstorming condition scored higher than the combined techniques on ten of fifteen possible comparisons with the five selected variables.

7. The single non-brainstorming techniques scored less than their respective combined techniques on ten of fifteen possible comparisons.

8. The brainstorming - forward-backward combination technique was judged superior to the two other combined techniques on nine out of ten comparison (the remaining case was tied) with the selected variables.

As understanding of a technique is an important prerequisite to its effective employment, high and low performers on each technique were contrasted on the extent to which they understood the technique. The following three tables present the results of that analysis.
TABLE 4.12  Understanding as a Moderator of Performance on each of the Stimulation Techniques - Experiment 1

<table>
<thead>
<tr>
<th>Technique</th>
<th>Mean Understand.</th>
<th>Performance on Dunker Problem</th>
<th>Performance on Dunn Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Below Mean U.</td>
<td>Above Mean U.</td>
</tr>
<tr>
<td>Control</td>
<td>8</td>
<td>2.08(6)</td>
<td>1.17(6)</td>
</tr>
<tr>
<td>Brainstorming</td>
<td>9</td>
<td>3.08(6)</td>
<td>3.08(6)</td>
</tr>
<tr>
<td>Analogy</td>
<td>7</td>
<td>1.08(6)</td>
<td>1.75(6)</td>
</tr>
<tr>
<td>Frwd-bkwrd</td>
<td>7</td>
<td>0.00(7)</td>
<td>1.16(5)</td>
</tr>
<tr>
<td>Morph.</td>
<td>8</td>
<td>0.00(5)</td>
<td>1.10(5)</td>
</tr>
</tbody>
</table>

Cell numbers represent mean rating scores and bracketed numbers represent the number in each grouping.

TABLE 4.13  Understanding as a Moderator of Performance on each of Stimulation Techniques - Experiment 2

<table>
<thead>
<tr>
<th>Technique</th>
<th>Mean Understand</th>
<th>Performance on Dunker Problem</th>
<th>Performance on Maier Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Below Mean U.</td>
<td>Above Mean U.</td>
</tr>
<tr>
<td>Control</td>
<td>8</td>
<td>.60(5)</td>
<td>.85(7)</td>
</tr>
<tr>
<td>Brainstorming</td>
<td>9</td>
<td>.72(6)</td>
<td>.17(6)</td>
</tr>
<tr>
<td>Analogy</td>
<td>7</td>
<td>1.08(6)</td>
<td>.92(6)</td>
</tr>
<tr>
<td>Frwd-Bkwrd</td>
<td>7</td>
<td>1.20(7)</td>
<td>2.20(5)</td>
</tr>
<tr>
<td>Morphol.</td>
<td>8</td>
<td>0.00(9)</td>
<td>.33(3)</td>
</tr>
</tbody>
</table>

Table 17 presents a summarization of many of the main ideas in Tables 15 and 16.
<table>
<thead>
<tr>
<th>Techniques</th>
<th>Dunker* Problem</th>
<th>Dunn Problem</th>
<th>Maier Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.0 (.12)</td>
<td>24.2 (20.6)</td>
<td>10.6 (10.1)</td>
</tr>
<tr>
<td>Brainstorming</td>
<td>1.9 (1.8)</td>
<td>24.4 (24.5)</td>
<td>4.1 (10.6)</td>
</tr>
<tr>
<td>Analogy</td>
<td>1.3 (1.2)</td>
<td>11.1 (9.0)</td>
<td>12.1 (8.0)</td>
</tr>
<tr>
<td>Forward-Backward</td>
<td>1.7 (1.1)</td>
<td>19.7 (19.9)</td>
<td>11.4 (10.9)</td>
</tr>
<tr>
<td>Morphology</td>
<td>.8 (.3)</td>
<td>31.4 (27.4)</td>
<td>5.7 (5.3)</td>
</tr>
</tbody>
</table>

*Dunker scores are weighted average of experiment 1 and experiment 2 results on above mean understanding. Bracketed figures are raw score results for all level of understanding.
The results of the three tables suggest the following:

1. With the three relatively unresearched techniques (analogy, forward-backward, and morphology), it was found that those who reported more general understanding scored better on problems (i.e. seven out of nine cases).

2. With the control and brainstorming conditions reported understanding did not seem to affect actual performance.

In Summary

Most of the observations above relate to one very basic and important question: how well did the technique inductions work? On one hand, the questionnaire data would lead one to conclude that the technique instructions were followed and that problem-solving behaviors were altered in predictable directions. But, on the other hand, the evidence would suggest that the techniques were not utilized as effectively as were the control and brainstorming instructions.

4.4 The Questionnaire Data: Eliminating Alternative Explanations

Creative problem-solving performance has been partially accounted for in terms of the technique applied, level of technique understanding, technique problem compatibility and order of problem presentation. Alternative explanations for solution quality abound. This section of the chapter tests whether or not certain questionnaire variables such as subjects' reported effort expenditures account for additional performance variance which may be attributable to other factors. To this end a multiple regression analysis
was conducted with the performance ratings as dependent variables and the thirteen questionnaire index variables as independent variables. Tables 4.15 through 4.18 present the results of this analysis.

The most important observation to be made from this analysis is that none of the thirteen variables consistently acts as even a fair predictor of performance. As a result, one would feel more confident in concluding that the techniques and not the other factors tapped by the questionnaire accounted for performance variations.

### TABLE 4.15 Regression on Dunker Problem Ratings - 1st Experiment

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>MULTIPLE R</th>
<th>R SQUARE</th>
<th>RSQ CHANGE</th>
<th>SIMPLE R</th>
<th>B</th>
<th>BETA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>.27</td>
<td>.07</td>
<td>.07</td>
<td>-.27</td>
<td>-.3</td>
<td>-.30</td>
</tr>
<tr>
<td>Evaluation</td>
<td>.34</td>
<td>.11</td>
<td>.04</td>
<td>-.17</td>
<td>-.3</td>
<td>-.25</td>
</tr>
<tr>
<td>Problem 1 improvement</td>
<td>.37</td>
<td>.14</td>
<td>.02</td>
<td>.19</td>
<td>.14</td>
<td>.21</td>
</tr>
<tr>
<td>Effort on Prob. 1</td>
<td>.39</td>
<td>.14</td>
<td>.02</td>
<td>-.03</td>
<td>-.54</td>
<td>-.23</td>
</tr>
<tr>
<td>Techniques Appreciation</td>
<td>.41</td>
<td>.17</td>
<td>.02</td>
<td>.03</td>
<td>-.06</td>
<td>-.17</td>
</tr>
<tr>
<td>Problem I Appreciation</td>
<td>.43</td>
<td>.19</td>
<td>.02</td>
<td>.09</td>
<td>.11</td>
<td>.15</td>
</tr>
<tr>
<td>Understanding</td>
<td>.43</td>
<td>.19</td>
<td>.00</td>
<td>.11</td>
<td>.08</td>
<td>.07</td>
</tr>
<tr>
<td>Elaboration</td>
<td>.44</td>
<td>.19</td>
<td>.00</td>
<td>.11</td>
<td>-.00</td>
<td>-.02</td>
</tr>
</tbody>
</table>
### Table 4.16 Regression on Dunker Problem Ratings - 2nd Experiment

<table>
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<th>R SQUARE</th>
<th>RSQ CHANGE</th>
<th>SIMPLE R</th>
<th>B</th>
<th>BETA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>.24</td>
<td>.06</td>
<td>.06</td>
<td>-.24</td>
<td>-.3</td>
<td>-.28</td>
</tr>
<tr>
<td>Technique</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appreciation</td>
<td>.33</td>
<td>.11</td>
<td>.05</td>
<td>.13</td>
<td>.06</td>
<td>.26</td>
</tr>
<tr>
<td>Effort on</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Prob. 1</td>
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<td>.15</td>
<td>.04</td>
<td>.15</td>
<td>.48</td>
<td>.26</td>
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<td>Problem 1</td>
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<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Improvement</td>
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<td>.17</td>
<td>.02</td>
<td>-.12</td>
<td>-.11</td>
<td>-.19</td>
</tr>
<tr>
<td>Evaluation</td>
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<td>.18</td>
<td>.02</td>
<td>-.12</td>
<td>-.11</td>
<td>-.19</td>
</tr>
<tr>
<td>Analysis</td>
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<td>.19</td>
<td>.00</td>
<td>-.01</td>
<td>-.00</td>
<td>.04</td>
</tr>
<tr>
<td>Elaboration</td>
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<td>.19</td>
<td>.00</td>
<td>.06</td>
<td>-.00</td>
<td>-.03</td>
</tr>
<tr>
<td>Understanding</td>
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<td>.19</td>
<td>.00</td>
<td>-.03</td>
<td>-.02</td>
<td>.02</td>
</tr>
</tbody>
</table>

### Table 4.17 Regression on Dunn Problem Ratings

<table>
<thead>
<tr>
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<th>MULTIPLE R</th>
<th>R SQUARE</th>
<th>RSQ CHANGE</th>
<th>SIMPLE R</th>
<th>B</th>
<th>BETA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem 2</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improvement</td>
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<td>.05</td>
<td>.05</td>
<td>.22</td>
<td>.62</td>
<td>.16</td>
</tr>
<tr>
<td>Elaboration</td>
<td>.27</td>
<td>.07</td>
<td>.02</td>
<td>.17</td>
<td>.11</td>
<td>.18</td>
</tr>
<tr>
<td>Understanding</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evaluation</td>
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<td>.09</td>
<td>.02</td>
<td>.22</td>
<td>1.18</td>
<td>.17</td>
</tr>
<tr>
<td>Effort on</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prob. 2</td>
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<td>.11</td>
<td>.01</td>
<td>.08</td>
<td>.08</td>
<td>.13</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appreciation</td>
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<td>.12</td>
<td>.01</td>
<td>.07</td>
<td>-.28</td>
<td>-.15</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appreciation</td>
<td>.35</td>
<td>.12</td>
<td>.00</td>
<td>.08</td>
<td>.34</td>
<td>.09</td>
</tr>
<tr>
<td>Time</td>
<td>.36</td>
<td>.13</td>
<td>.00</td>
<td>.13</td>
<td>.04</td>
<td>.04</td>
</tr>
</tbody>
</table>
TABLE 4.18  Regression on Maier Problem

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>MULTIPLE R</th>
<th>R SQUARE</th>
<th>RSQ CHANGE</th>
<th>SIMPLE R</th>
<th>B</th>
<th>BETA</th>
</tr>
</thead>
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<tr>
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<td>.05</td>
<td>.05</td>
<td>.23</td>
<td>3.39</td>
<td>.35</td>
</tr>
<tr>
<td>Analysis</td>
<td>.27</td>
<td>.07</td>
<td>.02</td>
<td>-.13</td>
<td>-.15</td>
<td>-.27</td>
</tr>
<tr>
<td>Technique Appreciation</td>
<td>.32</td>
<td>.10</td>
<td>.03</td>
<td>-.02</td>
<td>-.23</td>
<td>-.15</td>
</tr>
<tr>
<td>Elaboration</td>
<td>.34</td>
<td>.11</td>
<td>.01</td>
<td>-.06</td>
<td>-.06</td>
<td>-.11</td>
</tr>
<tr>
<td>Time</td>
<td>.36</td>
<td>.13</td>
<td>.01</td>
<td>-.04</td>
<td>-.11</td>
<td>-.16</td>
</tr>
<tr>
<td>Understanding</td>
<td>.36</td>
<td>.13</td>
<td>.01</td>
<td>-.04</td>
<td>-.62</td>
<td>-.13</td>
</tr>
<tr>
<td>Problem 2 Improvement</td>
<td>.38</td>
<td>.14</td>
<td>.01</td>
<td>.07</td>
<td>.43</td>
<td>.13</td>
</tr>
<tr>
<td>Evaluation</td>
<td>.38</td>
<td>.14</td>
<td>.00</td>
<td>.06</td>
<td>.03</td>
<td>.04</td>
</tr>
<tr>
<td>Problem 2 Appreciation</td>
<td>.38</td>
<td>.14</td>
<td>.00</td>
<td>.05</td>
<td>-105</td>
<td>.02</td>
</tr>
</tbody>
</table>

4.5 Summary Discussion of Results

The results reported above suggest six points worthy of being highlighted:

1. It is probable that subjects were utilizing the techniques they were instructed to use. F-tests discovered significance between techniques variance on two of the three problems. Furthermore, the evidence from section 4.3 suggests that the inductions were followed.

2. Such differences in performance which were to be found between techniques were not large, and seemed to be substantially affected by technique comprehension.
3. At least one of the techniques (morphology) proved interactive with problems to which it was applied.

4. The performance generated by the combined techniques was roughly equivalent to brainstorming although subject generally rated them of marginally lower value than brainstorming.

5. It would appear that subjects became either fatigued and/or frustrated in the one and one-half hour session, and as a result performed more poorly upon the second problem.

6. Alternative explanations for the technique effects could not be found by predicting rating scores with questionnaire variables. This finding along with the low inter-score correlation between the two problems, suggests internally validity. (Campbell and Stanley, 1963).
Chapter 5. Conclusions and Implications

The purposes of this chapter are twofold: (1) to more generally describe the experimental findings, and (2) to suggest directions for future research. Hence, the chapter is organized around two models. The first model describes the pattern of variables seemingly influencing subject performance in the current experiment. The second model, an adaptation of model I, was derived from the theory and research reviewed in chapters one and two in addition to the experimental results of chapter 4. This model is intended as a more general description of creative problem-solving effectiveness with direct implications for future research.

5.1 Modelling the Findings of the Experimental Study

A number of variables were found to have either a direct or an indirect impact upon creative performance. Although C.S.T.'s were generally found to augment performance, the degree of their usefulness tended to be moderated by the problem being solved and to be mediated by the degree of technique comprehension.* In addition, it appears that a fatigue or frustration factor was also influencing performance. Model I, on the next page, presents a conception of the factors affecting creative performance.

* Both moderating and mediating variables purport to interact with independent variables upon dependent variables. However, mediating variables make the additional claim of explaining at least part of the causal process initiated by an independent variable and consequently mediating the independent and dependent variables.
MODEL 1: The Determinants of Creative Performance: From an experimental study

C.S.T (s) -> C.S.T. Comprension -> Creative Performance

Nature of Problem

Fatigue or Frustration
The causal relationship between C.S.T. utilization and performance is evidenced in the significance between C.S.T. treatment differences on two of the three problems (pp. 107-108). Furthermore, subjects acknowledge spending 50% of their problem-solving time utilizing techniques of which they claim average understanding in aggregate.

The belief that C.S.T. effectiveness was mediated by technique understanding is evidenced in higher performance scores with treatment conditions under conditions of high understanding (pp. 120-121). This finding is not surprising given the complexity of the techniques and the brevity of the induction period.

The suggestion that C.S.T. effectiveness was moderated by problem type is born out in the technique X problem interaction with morphology and to a lesser degree with analogy. Morphology proved to be ineffective on the Dunker and Maier problems but very effective with the Dunn problems. In the case of this experiment, morphology was constructed so as to have the student subject dimensionalize the 'solution space' for the problem. In effect, morphology was constructed herein to act, at least initially, as a final state elaboration technique. With the Dunker problem* (often characterized as an insight problem) grasping the solution space enough to dimensionalize it may be as difficult as trying to solve it directly. Therefore it shouldn't be too surprising that morphology failed to perform well with the tumor problem. An entirely different form of explanation

*n.b. The Dunker tumor problem was utilized by Crovitz (1970) to illustrate the relational algorithm technique which has previously been classified as an initial state elaboration technique (p. ).
is required to explain the differential performance of morphology upon the two realistic problems. The Maier change-of-work process problem is an organizational behavior or management problem whereas the Dunn sales problem is a marketing problem. In commerce faculties in general and at U.B.C. in particular, Marketing is taught as a somewhat more normative discipline than is Organizational Behavior. As a result it would have been less difficult for Commerce student subjects to conceptualize and then dimensionalize a solution space with the Dunn problem than it would with the Maier problem. The analogy technique also proved to be somewhat interactive. Analogy proved to be somewhat more effective on the Dunker and Maier problems than with the Dunn problem. This may partially be explained in terms of one function of analogies (i.e. to make the strange, familiar (p. 75) )given that the Dunker tumor problem, at least, is likely to appear foreign to Commerce students. Personal analogy probably proved valuable in the case of the Maier problem - with the subjects imagining themselves as one of the workers. Maier has utilized this problem to illustrate the value of role playing - an activity conceptually similar to personal analogy.

Finally, model I illustrates that fatigue or frustration probably have a performance consequence. This relationship is born out in the decline in performance between the solution of the first problem and the solution of the second problem (p. 102). The result occurred despite attempts on the part of the experimenter to produce a learning effect or performance increment from the first to the second problem (p. 92).

Model I is not general enough or complete enough to provide much in the way of direction for future researchers.
5.2 Modelling the Determinants of Creative Performance

Model II was created as a more general model of the determinants of creative performance than Model I from which it was adapted. Model II is different from its predecessor in a number of ways: (1) it utilizes eight rather than five variables; (2) its variables are generally more broadly conceptualized; (3) it utilizes three rather than two causal determinants of creative performance; and (4) it contains two causal paths linking the C.S.T.(s) to creative performance.

The first new variable to be added to the new model is that of 'creative skills'. Creative skills, such as that of tolerating ambiguity, are described in some detail in section 1.6 (pages 16-21).

The 'creative abilities' variable is contained in the model more for the sake of explaining creative skills than for describing the functioning of C.S.T.'s. As a result, the creative abilities variable may be somewhat more redundant in the design of C.S.T. research than would the other variables in the model. For a description of the various creative abilities the reader is referred to Gulford and Hoepfner ('71).

The third new variable in the model is that of 'stages in the creative process'. More than one conception of the creative problem-solving process is acceptable as is illustrated by the creative process heuristics technique (pages 3-5). One detailed conception of the creative process is available in section 1.7 (pages 21-23) of chapter one.

Three of the remaining variables in the model have been modified from Model I. 'Technique understanding' was broadened to 'competence in use of technique'. As was stated earlier (page 1) substantial training might be required with some techniques before the subject is considered competent
MODEL 2: Directions For Future Research

Creative Abilities

Creative Problem-Solving Skills

Creativity Stimulation Techniques

Competence in Use of Techniques

Creative Performance

Problem Type

Stage in Problem-Solving Process

Fatigue
in its usage. The competence criterion is somewhat more demanding than that of merely understanding the technique instructions. Furthermore, the 'nature of problem' variable was refined somewhat to a 'type of problem' variable which suggests the necessity for developing a taxonomy of realistic organizational problems requiring creative solutions. Section 1.5 (pages 12-15) contains an initial attempt to provide a useful taxonomy of problem types. Finally the 'fatigue or frustration' variable was narrowed to only 'fatigue'. Overcoming frustration stemming from such factors as ambiguity and uncertainty may be considered part of the 'creative problem-solving skills' variable. As little has been done in attitude research to explore self-perceptions of one's energy level, it would be necessary to construct such a scale before research might be conducted on fatigue or low energy.

The addition of a causal path from the C.S.T.(s) variable through creative problem-solving skills to creative performance requires some explanation. It may be claimed that C.S.T.'s function by augmenting one's creative skills as was argued in Section 1.6. However, one would not expect these skills to interact substantially with problems as resulted in the experiment, therefore, one should probably distinguish two aspects of each C.S.T.: (1) a cognitive aspect, as is illustrated by changes in creative skills, and (2) a mechanical aspect which specifies that one follow certain procedural steps. Some techniques emphasize the cognitive such as free association or brainstorming, where others, such as morphology emphasize the mechanical.

Model II suggests a number of areas for future research, namely:

1. developing viable taxonomies: of creative skills, of problem types, and of the creative process.
2. discovering and specifying the interaction effects of problem types and process stages with C.S.T.'s upon performance.

3. determining the importance of creative skills to the effectiveness of techniques.

4. determining the impact of fatigue (or alternatively of energy level) upon creative performance.

5. determining the importance of experience in the use of C.S.T.

The conclusion to this thesis appears more like a beginning than an ending. Maybe this is how it should be. I would then hope that this research would springboard others to more valuable discoveries in the future.
BIBLIOGRAPHY


Loulser, Jan J. and M. Fullan: Industrial Conversation and Worker Attitudes to Change in Different Industries. (Task Force on Labour Relations), Queens Printer, Ottawa, 1970.


TECHNIQUE INSTRUCTIONS

 Attempt to produce creative solutions to the problem which you are given. Look for answers which are both original and potentially practical.

1. After you receive the problem generate as many good answers as possible for the problem.

2. Mark the most promising ideas with an asterisk (*).

3. Select one of the most promising ideas and develop it more fully.
TECHNIQUE INSTRUCTIONS

Attempt to produce creative solutions to the problem which you are given by using the "brainstorming" technique below.

Follow the instructions in order to stimulate your thinking.

WRITE YOUR IDEAS FREELY AND WITHOUT REGARD TO QUALITY. GO FOR QUANTITY. THE WILDER THE IDEAS THE BETTER. LET YOURSELF GO. DON'T BE CRITICAL.

DEFER JUDGING YOUR IDEAS UNTIL YOU HAVE GENERATED A SUBSTANTIAL NUMBER OF POTENTIAL SOLUTIONS.
TECHNIQUE INSTRUCTIONS

Attempt to produce creative solutions to the problem which you are given by using the "analogy" technique below.

Follow the instructions in order to stimulate your thinking.

An analogy is a partial similarity between two objects or processes. For example, "the heart is like a pump" and "governing a state is like captaining a ship" are both analogies. Both of these analogies can be extended so as to increase one's knowledge of the heart or of government.

When people are faced with a strange problem they often unknowingly use analogies when they reformulate the problem in familiar terms. One can use analogies also to make what is initially too familiar, strange and thereby obtain another slant on a problem.

There are three ways in which you can use analogies to help you solve problems.

I Direct Analogy

Look for 'direct analogies' to the problem whether from within your realm of experience or from your imagination. Use objective and impersonal images to describe the problem.

Hint: practice completing the following sentences:

1. "This problem is like .....(other problem of your experience or imagination)....."

2. "This object or process (in problem) is like ..........(some other object or process)".

II Personal Analogy

Think of yourself as being within the problem as different inanimate objects or persons contained in it. Explore your way through the problem in this way.

For example, a creative chemist might think of himself as a molecule, permitting himself to be pushed and pulled by the molecular forces.

cont'd....
III  Fantasy Analogy

Ask yourself how in your wildest fantasies you might have the the problem solved.  'Fantasy Analogy' is quite simply the child's game of "let's pretend", conjuring up the ideal solution to the problem, pretending it will work, and then seeing if you can find a way to make it work roughly as you had imagined.

Use each of these three methods in turn to aid you in your problem solving.
TECHNIQUE INSTRUCTIONS

Attempt to produce creative solutions to the problem which you are given by using the "foreward-backward" technique below.

Follow the instructions in order to stimulate your thinking.

Think of a problem as having two states, its initial state (I) and its final state (F).

Diagram

\[
\begin{array}{c}
\text{Initial State} \\
\text{I} \\
\text{where you are now} \\
\text{foreward problem solving} \\
\end{array} \quad \begin{array}{c}
\text{Final State} \\
\text{F} \\
\text{the point you wish to reach} \\
\text{backward problem solving} \\
\end{array}
\]

If one starts with an analysis of whatever information he possesses on the problem and works towards a solution he is involved in foreward problem-solving.

If, on the other hand, one begins with a description of the solution he wishes to reach (the final state) and works backwards to the information he possesses, he is involved in backward problem-solving.

Steps to follow:

I Foreward Problem-Solving

1. Bring together whatever information you have on the problem both from the problem description and from your own memory.
2. Reformulate the problem in terms of your enlarged knowledge.
3. Attempt to provide solutions to the problem.
   - after spending some time exhausting possibilities with Foreward problem-solving, write down possible answers.

II Backward Problem-Solving

1. Describe the characteristics of a good final state to this problem - you might even imagine ideal final states. Formulate some possible alternatives.
2. Now work backward to see what would have to be true for these final states to be possible.
3. Write down solutions which might occur to you.
TECHNIQUE INSTRUCTIONS

Attempt to produce creative solutions to the problem which you are given by using the morphology technique.

Follow the instructions to stimulate your thinking.

For any problem, there exists a set of possible answers. This set of possibly appropriate answers is called a SOLUTION SPACE. A description of the solution space will describe the characteristics of any answer to the problem.

If our problem is to design a dress, then the solution space contains the set of all possible dresses. If we were to describe the solution space we would have to describe dresses, in general.

Morphology is a technique which requires you to describe the solution space in terms of its basic dimensions. For example, the basic dimensions of a dress might be: (1) color, (2) fabric, (3) function, etc.

When one uses the morphology technique he arranges the dimensions in a horizontal array as follows and then adds key values under each dimension.

<table>
<thead>
<tr>
<th>Dimension 1</th>
<th>Dimension 2</th>
<th>Dimension 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>(color)</td>
<td>(fabric)</td>
<td>(function)</td>
</tr>
<tr>
<td>value 1</td>
<td>value 2</td>
<td>value 3</td>
</tr>
<tr>
<td>black</td>
<td>cotton</td>
<td>formal wear</td>
</tr>
<tr>
<td>blue</td>
<td>linen</td>
<td>informal evening wear</td>
</tr>
<tr>
<td>green</td>
<td>rayon</td>
<td>casual wear</td>
</tr>
<tr>
<td>red</td>
<td>wool</td>
<td>sports wear</td>
</tr>
<tr>
<td>orange</td>
<td>etc.</td>
<td>etc.</td>
</tr>
<tr>
<td>yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>white</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To use this morphological schema in creative problem solving, follow the directions below:

(1) take one value from under each dimension and combine into a 'multi-variable concept', e.g. a black, cotton, evening wear clothing design. (With this particular schema two or more values could be drawn from each dimension, e.g., black and blue, wool and cotton casual wear design).

(2) Look constructively at the multi-variable concept obtained, thinking how such an idea might be made feasible. Adapt this new idea as is necessary.

cont'd.....
Therefore to use morphology:

1. Describe the set of all possible solutions in terms of a few basic dimensions.

   Hint: ask yourself what characteristics any answer to the problem must have.

2. Place important values on each dimension chosen and set up the morphological schema as follows:

   \[
   \begin{array}{ccc}
   \text{Dimension 1} & \longrightarrow & \text{Dimension 2} \\
   \text{name} & \text{name} & \\
   \text{value 1} & \text{value 1} & \\
   \text{value 2} & \text{value 2} & \\
   \text{value 3} & \text{value 3} & \\
   \downarrow & \downarrow & \\
   \end{array}
   \]

3. Create 'multi-variable concepts' by drawing a value from under each dimension.

4. Think about each 'multi-variable' concept constructively and adapt it as you see fit.
**TECHNIQUE INSTRUCTIONS**

Attempt to produce creative solutions to the problem which you are given by using the "brainstorming" and the "morphology" techniques below.

Follow the instructions in order to stimulate your thinking.

**Brainstorming Instructions**

WRITE YOUR IDEAS FREELY AND WITHOUT REGARD TO QUALITY. GO FOR QUANTITY. THE WILDER THE IDEAS THE BETTER. LET YOURSELF GO. DON'T BE CRITICAL.

DEFER JUDGING YOUR IDEAS UNTIL YOU HAVE GENERATED A SUBSTANTIAL NUMBER OF POTENTIAL SOLUTIONS.

**Morphology Instructions**

For any problem, there exists a set of possible answers. This set of possibly appropriate answers is called a SOLUTION SPACE. A description of the solution space will describe the characteristics of any answer to the problem.

If our problem is to design a dress, then the solution space contains the set of all possible dresses. If we were to describe the solution space we would have to describe dresses, in general.

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<th>etc.</th>
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<tr>
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<td>wool</td>
<td>sports wear</td>
</tr>
<tr>
<td>etc.</td>
<td>orange</td>
<td>etc.</td>
<td>etc.</td>
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cont'd......
(2) Look constructively at the multi-variable concept obtained, thinking how such an idea might be made feasible. Adapt this new idea as is necessary.

Therefore, to use morphology:

(1) Describe the set of all possible solutions in terms of a few basic dimensions.

Hint: ask yourself what characteristics any answer to the problem must have.

(2) Place important values on each dimension chosen and set up the morphological schema as follows:

\[
\begin{array}{c}
\text{Dimension 1} \quad \cdots \quad \text{Dimension 2} \\
\text{(name)} & (name) \\
\text{value 1} & \text{value 1} \\
\text{value 2} & \text{value 2} \\
\text{value 3} & \text{value 3} \\
\end{array}
\]

(3) Create 'multi-variable concepts' by drawing a value from under each dimension.

(4) Think about each 'multi-variable concept' constructively and adapt it as you see fit.
TECHNIQUE INSTRUCTIONS

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Forward-Backward Instructions

Think of a problem as having two states, its initial state (I) and its final state (F).

Diagram

```
          Initial State          Final State
  [I]------------------------<----------------[F]
where you are now forward problem solving backward problem solving
the point you wish to reach
```

If one starts with an analysis of whatever information he possesses on the problem and works towards a solution he is involved in forward problem-solving.

If, on the other hand, one begins with a description of the solution he wishes to reach (the final state) and works backwards to the information he possesses, he is involved in backward problem-solving.

Steps to follow:

I  Forward Problem-Solving

(1) Bring together whatever information you have on the problem both from the problem description and from your own memory.

(2) Reformulate the problem in terms of your enlarged knowledge.

(3) Attempt to provide solutions to the problem.

- after spending some time exhausting possibilities with Forward problem-solving, write down possible answers.

cont'd...
II  Backward Problem-Solving

(1) Describe the characteristics of a good final state to this problem — you might even imagine ideal final states. Formulate some possible alternatives.

(2) Now work backward to see what would have to be true for these final states to be possible.

(3) Write down solutions which might occur to you.
TECHNIQUE INSTRUCTIONS

Attempt to produce creative solutions to the problem which you are given by using the "brainstorming" and the "analogy" techniques below.

Follow the instructions in order to stimulate your thinking.

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Analogy Instructions

An analogy is a partial similarity between two objects or processes. For example, "the heart is like a pump" and "governing a state is like captaining a ship" are both analogies. Both of these analogies can be extended so as to increase one's knowledge of the heart or of government.

When people are faced with a strange problem they often unknowingly use analogies when they reformulate the problem in familiar terms. One can use analogies also to make what is initially too familiar, strange and thereby obtain another slant on a problem.

There are three ways in which you can use analogies to help you solve problems.

I. Direct Analogy

Look for 'direct analogies' to the problem whether from within your realm of experience or from your imagination. Use objective and impersonal images to describe the problem.

Hint: practice completing the following sentences:

1. "This problem is like ..... (other problem of your experience or imagination) ......

2. "This object or process (in problem) is like .... (some other object or process)"

II. Personal Analogy

Think of yourself as being within the problem as different inanimate objects or persons contained in it. Explore your way through the problem in this way.

For example, a creative chemist might think of himself as a molecule, permitting himself to be pushed and pulled by the molecular forces.

cont'd...
III. Fantasy Analogy

Ask yourself how in your wildest fantasies you might have the problem solved. 'Fantasy Analogy' is quite simply the child's game of "let's pretend", conjuring up the ideal solution to the problem, pretending it will work, and then if you can find a way to make it work roughly as you had imagined.

Use each of these three methods in turn to aid you in your problem solving.
By what procedures might one get rid of an inoperable stomach tumor without destroying the healthy body tissue if:

1. there are rays which will destroy organic tissue at sufficient intensity whether the tissue is healthy or tumorous.

2. the rays can be modulated in intensity.

1. Utilize technique instructions to aid you in finding possible solutions to the problem. Write your answers on the general answer sheet provided. AT THIS STAGE GO FOR QUANTITY OF IDEAS.

2. Mark those ideas which are most promising with asterisks (*), i.e., those ideas which are both at least somewhat original and somewhat feasible.

3. Select the idea or combination of ideas which you consider to be the most creative. Develop your selection more fully on the proposal form. AT THIS STAGE WORK TOWARDS QUALITY.
Salesman Bill Knowland

Bill Knowland has been a salesman for the United Steel Form Company for five years. The company sells standard and special steel forms to the construction industry. One of Bill's important customers is the Gerry Construction Company, a large general contracting firm that builds offices, plants, and public buildings.

During a recent call on Gerry's purchasing agent, Bill hears that the company has won the bid for construction of a new aircraft component plant to be built in his territory. The purchasing agent tells him that his immediate concern is arranging for a reliable supply of a certain steel support form for the shell of the plant. United and all of its competitors manufacture this form to standard specifications. In effect, the P.A. warns Bill that he will soon be asking all suppliers for a price on this form, and that the order will be a large one.

After the call, Bill begins to study the problem. His company has recently raised the price on this item, and this is the first time he has had a problem working with the new price. One large competitor has followed the price rise, but the rest of the industry has not. In addition, Bill knows that the item is standard throughout the industry and that his company as well as most of its competitors can make delivery on time and in the required quantities. United has a firm policy under which all customers are charged the same price for each item in the line.

As he considers his problem, Bill wonders, "How in hell do you sell a standard item to an important customer in large amounts without any product or service advantages and at a price above some of your competitors?"

Salesman Bill Knowland stands in need of a good, creative solution to his sales problem! What steps might Bill take to solve his problem?

approx. 20 min.

1. Utilize technique instructions to aid you in finding possible solutions to the problem. Write your answers on the general answer sheet provided. AT THIS STAGE GO FOR QUANTITY OF IDEAS.

approx. 10 min.

2. Mark those ideas which are most promising with asterisks (*), i.e. those ideas which are both at least somewhat original and somewhat feasible.

3. Select the idea or combination of ideas which you consider to be the most creative. Develop your selection more fully on the proposal form. AT THIS STAGE WORK TOWARDS QUALITY.
In a large firm which manufactures communications equipment, a four man department has the responsibility for the entire production of a particular component. Three of the men perform the assembly work and the fourth acts as foreman. The assembly operation is divided into three positions and the workers have adopted a system of hourly rotation among the three jobs. The three jobs are not entirely routine and require somewhat different skills. However, all three of the men have been able to master each of the jobs at least minimally well but still perform some jobs better than others.

The foreman has called a meeting to discuss the possibility of their changing their work method to one where each man works on only one position. This would be his best position according to the time study data given to the foreman. Although the new method should increase the productivity of the workers and thus their piece rate wages, the foreman's suggestion of a change to the new method was met with some resistance. The employees were concerned about the amount of boredom resulting from working at the same job all the time and believed that this might actually lower production. They were also a bit suspicious of management's motives in suggesting the new work method.

Can you suggest any solution to the problem faced by the foreman and his crew?

approx. 1. Utilize technique instructions to aid you in finding possible solutions to the problem. Write your answers on the general answer sheet provided. AT THIS STAGE GO FOR QUANTITY OF IDEAS.

2. Mark those ideas which are most promising with asterisks (*), i.e., those ideas which are both at least somewhat original and somewhat feasible.

approx. 10 min.

3. Select the idea or combination of ideas which you consider to be the most creative. Develop your selection more fully on the proposal form. AT THIS STAGE WORK TOWARDS QUALITY.
1st QUESTIONNAIRE

Instructions: Circle the number or check the box most closely representing your opinion.

1. Was the creativity stimulation technique understandable from the instructions given?
   - poorly understandable
   - very understandable

2. Were the instructions complete enough to provide enough understanding to use the technique on the problem?
   - insufficient instructions
   - instructions sufficiently complete

3. Approximately how many minutes did you spend using the technique? _____ min.

4. How effective did you find the technique instructions for the problem at hand?
   - totally ineffective
   - very effective

5. Do you feel your problem-solving performance was improved by the technique instructions given?
   - not improved at all
   - improved a lot

6. How did you find the problem which you were given?
   - (a) uninteresting
   - (b) unrealistic
   - (c) unenjoyable

7. How much effort did you put into this problem-solving task?
   - little
   - much

8. How would you rate your performance?
   - poor
   - good

9. How creative would you think your answers were in general?
   - not creative at all
   - very creative

cont'd....
10. How confident were you that you could provide good answers to the problem when you first saw it?

   confidence               1  2  3  4  5  6  7  very confident
   almost no

11. How creative would you think your answers were in general?

   not creative               1  2  3  4  5  6  7  very creative
   at all

   How creative was your one elaborated answer?

   not creative               1  2  3  4  5  6  7  very creative
   at all

12. How did you spend your time?

   Percent of time spent analyzing problem
   Percent of time spent generating possible answers
   Percent of time evaluating possible solutions
   Percent of time elaborating on chosen answer
   Other

13. How difficult did you find the problem?

   difficult               1  2  3  4  5  6  7  easy

14. Did you find the time available was adequate to provide reasonable solutions to the problem?

   very                     1  2  3  4  5  adequate
   inadequate

15. Comments on technique:

   
   
   
   

16. Comments on problem:

   
   
   
   

cont'd...
16. cont'd:

17. General Comments:
2nd QUESTIONNAIRE

Instructions: Circle the number or check the box most closely representing your opinion.

1. How did you find the technique?
   - not very interesting
   - difficult to use
   - not very enjoyable to use

2. Do you feel you had a better mastery of the technique on the second problem?
   - much
   - less

3. How many minutes did you spend using the technique this time? ______ minutes

4. How effective did you find the technique for the problem at hand?
   - totally ineffective
   - very effective

5. Do you feel your problem-solving performance was improved by the technique given?
   - not improved at all
   - improved a lot

6. How did you find the problem which you were given?
   - (a) uninteresting
   - (b) unrealistic
   - (c) unenjoyable

7. How much effort did you put into this problem-solving task?
   - little
   - much

8. How would you rate your performance?
   - poor
   - good

9. How would you rate your ability in creative problem-solving?
   - poor
   - good

cont'd....
10. How confident were you that you could provide good answers to the problem when you first saw it?

   almost no confidence 1 2 3 4 5 6 7 very confident

11. How creative would you think your answers were in general?

   not creative at all 1 2 3 4 5 6 7 very creative

   How creative was your one elaborated answer?

   not creative at all 1 2 3 4 5 6 7 very creative

12. How did you spend your time?

   Percent of time spent analyzing problem
   Percent of time spent generating possible answers
   Percent of time evaluating possible solutions
   Percent of time elaborating on chosen answer
   Other

13. How difficult did you find the problem?

   difficult 1 2 3 4 5 6 7 easy

14. Did you find the time available was adequate to provide reasonable solutions to the problem?

   very 1 2 3 4 5 adequate
   inadequate

15. Comments on technique:

16. Comments on problem:

   cont'd...
16. cont'd:

17. General Comments:
### Questionnaire I

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Variable Abbreviations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Understand.</td>
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GENERAL ANSWER SHEET

(for your list of possible solutions)
PROPOSAL FORM

(for the development of your selected answer)