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ABSTRACT

The purpose of this study was to determine if a multi-media presentation facilitates synthetic responses. The variables, linearity and meaningfulness of the presentation, were studied using a 2 x 2 design with outside control. The five conditions were administered to 95 fifth graders. The synthetic responses were measured with three tasks. Task I consisted of a Similarities Judgment task, Task II was a Sorting task, and Task III consisted of a questionnaire about the presentation. An ANOVA performed on the data from the Similarity Judgment and Sorting tasks showed no significance. A chi-square performed on the questionnaire did show significance on some questions, but these results were too isolated to accurately interpret. Descriptive analysis of the data, however, showed slight trends which would suggest that a multi-media format does facilitate synthetic responses. (Author)

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Technical Report No. 216

THE EFFECT OF MULTIMEDIA PRESENTATION ON THE INDUCEMENT OF SYNTHETIC CONCEPTS

Report from the Semantic Components of Concept Learning Project

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STATEMENT OF FOCUS

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This Technical Report is from the Project on Variables and Processes in Cognitive Learning in Program 1, Conditions and Processes of Learning. General objectives of the Program are to generate knowledge and develop general taxonomies, models, or theories of cognitive learning, and to utilize the knowledge in the development of curriculum materials and procedures. Contributing to these Program objectives, this project has these objectives: to ascertain the important variables in cognitive learning and to apply relevant knowledge to the development of instructional materials and to the programming of instruction for individual students; to clarify the basic processes and abilities involved in concept learning; and to develop a system of individually guided motivation for use in the elementary school.

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Abstract

The purpose of this study was to determine if a multi-media presentation facilitates synthetic responses. The variables, linearity and meaningfulness of the presentation, were studied using a 2 X 2 design with outside control. The five conditions, Non-Random: Non-Linear, Non-Random: Linear, Random: Non-Linear, Random: Linear, and Control, were administered to 95 fifth graders.

The synthetic responses were measured with 3 tasks. Task I consisted of a Similarities Judgment Task where the Ss were asked to rate the similarity of all possible pairs of 16 stimuli pictures depicting various aspects of water. Task II was a Sorting Task where Ss freely sorted the 16 pictures and 3 sounds, and were then asked to explain their groupings. Task III consisted of a questionnaire about the presentation.

An ANOVA performed on the data from the Similarity Judgment and Sorting Tasks showed no significance. A chi-square performed on the questionnaire did show significance on some questions, but these results were too isolated to accurately interpret. Descriptive analysis of the data, however, showed slight trends which would suggest that a Non-Random: Non-Linear, i.e. multi-media, format does facilitate synthetic responses.

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Chapter I

INTRODUCTION

Definition of Synthesis

Traditional techniques of studying cognitive skills have, of necessity, been very simplistic in their approach. Thus, generalization of this research to educational practices is questionable. Carroll (1964), noting that cognitive research has nothing tangible to offer educators, lists the following among the important differences between experimental settings and schools, that makes this transfer impossible.

1. Concepts learned in school are genuinely new concepts and not just artificial combinations of familiar attributes.
2. New concepts learned in school usually depend on attributes which themselves represent difficult concepts.
3. Concepts learned in school are of a relational rather than of a conjunctive character.

This study, in order to deal in a relevant way with complex cognitive skills, studied the cognitive skill of synthesis as facilitated by multi-media (an audio-visual tool currently very popular in the schools).

Bloom (1956) was the first to describe the process of synthesis within a psychological context. Assigning it the fifth level in his Taxonomy of Learning, he defined synthesis as occurring when a

> Student must draw upon elements from many sources and put these together into a structure or pattern not clearly there before. His efforts should yield a product . . . something that can be clearly more than the materials he began to work with. (p. 162)

In a purely cognitive sense, I define synthesis as the process of combining two or more concepts (or experiences) into a higher order concept, more complex and more abstract. Therefore, the studying of synthesis, although a basic cognitive skill, should be more relevant in terms of everyday occurrences.

Synthesis can be thought of as an extension of the cognitive processes that traditionally have been studied. The following is a hypothetical model of the hierarchy of complexity in cognitive research. The first level is the traditional way of defining concept formation (e.g., Bruner, Goodnow, & Austin, 1956), where the task is to formulate the rules for exclusion and inclusion in a previously defined set of simple symbols by discovering the combination of dimensions peculiar to that set. For example, the subject is presented with different geometric shapes of various colors and sizes representing examples and non-examples of the concept, from which he must formulate the concept (e.g., blue triangleness).

A second level of cognitive research is substituting multidimensional symbols, i.e. words (Tabachnick et al. 1970), in the task of discovering the rules for exclusion or inclusion based on the specific dimensions.

A third level, for which there is no previous research, is a natural extension of the first two. It is the synthesis of a higher level concept from two or more lower level concepts (or experiences) rather than a search for the rules of inclusion or exclusion. Synthesis is not the discovery of a predetermined set, but the process of combining concepts and/or experiences into a unique whole. The dimensions of the synthesized concept are more than the sum of the dimensions of the concepts that are its basis. This process can be better understood in relation to simple categorization (or the sorting of concepts). The following concepts can be dealt with in two ways:

rain
cloud
water
ice

They can be categorized into gas (cloud), liquid (rain, water), and solid (ice); or they can be related in a synthetic response which recognizes that water manifests itself in many different forms. This can be further synthesized to state that seemingly diverse things can be in actuality different manifestations of the same thing. In the first process, the concepts are just sorted according to attributes and rules they already possess. Nothing new is added; the category liquid still exists whether the term "rain" is used or not. In synthesis, the concepts are related in "a structure . . . not clearly there before. (The synthesis) yields a product . . . something that is clearly more than the materials begun with." (Bloom, 1956.) Synthesis is the resolution of concepts or experiences which can be either seemingly compatible or incompatible.

Definition of Multi-media

The present study of synthetic thinking was conducted in the framework of a multi-media method for the presentation of information. Multi-media is defined here as a multi-screen presentation using films, slides, music, and narration presented simultaneously and in various combinations in a meaningful presentation. It differs from more traditional forms of audio-visual aids in its complexity (information density) and its non-linearity (ability to present simultaneous information) (Perrin, 1969). Multi-media is a controlled way to simulate reality with slides and music.

The technique of multi-media is amenable to the study of synthesis because the variables of synthesis can be easily manipulated. Linear versus non-linear presentation of information, density of information, temporal spacing of concepts, length of exposure to concepts, etc., are manipulated by placement and timing of the slides and sounds within the presentation.

Relevant Literature

The research literature in the areas of synthesis and multi-media is sparse. The only study dealing specifically with synthesis was one done by Kropp and Stoker (1966) to test the validity of Bloom's Taxonomy of Cognitive Processes. Their test consisted of two reading passages from the social sciences and two reading passages from the natural sciences, with questions on these passages that were divided into six sub-tests to test the six levels of the taxonomy (knowledge, comprehension, application, analysis, synthesis and evaluation). A Multiple-choice format was used in all sub-tests except synthesis and evaluation, where the author's inability to write multiple-choice questions necessitated the use of a free-response format. The answers were judged by trained scorers on a 0-4 point scale. The test was administered to approximately 1600 Ss at each grade level, 9-12. An analysis of the six sub-tests was performed to test the hypothesis that, since Bloom's taxonomy was hierarchical, the mean scores of the sub-tests would decrease as the taxonomy structure increased. The hypothesis was supported with the exception of the reversed order of synthesis and evaluation in the two natural science passages. This was attributed to the probable unreliability of the free-response format of the questions for these two sub-tests and the difficult natural science passages themselves. It is to be noted that Kropp and Stoker stressed the difficulty in writing valid and reliable test measures for synthesis.

Only three studies related to multi-media were located. The first is Allen & Cooney (1963) who studied the filmatic variable of non-linearity in teaching. They studied the "effects upon learning of (1) visual images presented non-linearly, that is, cumulatively or simultaneously; and (2) visual images presented linearly, that is, sequentially (p. 103)." The subject matter, the flowchart process used in computer programing and analogous processes in reality, was presented at various levels of abstraction. The Ss were tested for knowledge, comprehension, and application of the material with both immediate and delayed tests. There were six films prepared, three linear and three non-linear, for three levels of abstraction (factual, conceptual, and factual-conceptual mixture). These were presented to sixth and eighth graders. A correlation analysis was performed on the mean scores of the immediate and delayed test, as well as a factor analysis on the immediate test. They found that for sixth graders, the linear format of factual treatment of the subject was best, while a mixed factual-conceptual treatment of the subject was best facilitated with a non-linear presentation. For eighth graders, they found there was no difference between treatment (factual or conceptual) and format (linear and non-linear).

More relevant is a study done by Lombard (1969) on the "Multi-channel, Multi-image teaching of synthesis skills in eleventh grade U. S. History." His definition of synthesis, the understanding of a causal relationship of an historical event, is much narrower than the definition of synthesis as used in this study. The independent variable was linearity versus non-linearity (simultaneity) in the presentation. Two presentations, a one-screen and a three-screen (both with accompanying audio) were prepared and tested on eleventh grade history students. His measurement of synthesis skill consisted of the frequency of pairings for each possible pair of twenty historical events. The Ss were instructed to mark a check at the intersection of any two events they thought to be causal. The data were analyzed with an analysis of variance. The only significant result was that the three-screen presentation facilitated the ability to learn complex synthetic relationships in low ability girls. Lack of other significant results could be attributed to the sensitivity of the testing device to only pre-defined synthetic relationships.

The third study was done by Monahan (1966), in which the multi-media process, as well as the way to integrate it into the existing school system, was studied. The study tried to determine the gross effects of multi-media, and no attempt was made to study it in the context of cognitive skills. He compared math ability (high and low as measured by the STEP achievement test) with two presentations:

Version A, specifically written for high ability students, placed the responsibility for finding associations more heavily with the students; Version B, written for low ability students, had more visuals and was more explicit in presenting associations. It was found that high ability Ss performed equally well on both Versions A & B, low ability Ss performed best on Version B, and high ability Ss performed better than low ability Ss on Version A.

Thus, while the synthetic process has strong face validity, its study through the technique of multi-media has not revealed an empirical justification for its existence.

Overview of Present Study

The process of synthesis is not well understood. Though intuitively felt to be true as a cognitive activity, it is very difficult to define analytically. Nevertheless, it can be hypothesized that the occurrence of a recognizable synthetic response is contingent upon certain variables such as temporality, density, and affective components. Temporality is the distance (length of time) between concepts or experiences. The probability that a synthesis will occur increases as the temporal distance between the concepts or experiences diminishes. The temporal extreme of simultaneity allows for varying degrees of density.

As in any cognitive skill, there is also an important affective component. Diverse backgrounds and varying abilities to synthesize explains why the same situations are treated differently by different people. It is in essence a different experience for each individual. This explains why given a dense amount of information (information glut) some individuals synthesize all available concepts (information), some synthesize certain (and different) subsets, and some keep everything discrete (or just categorize). It also explains why dissonant concepts are synthesized by only some individuals.

This experiment was an attempt to research the process of synthesis. However, the limitations of measurement necessitated a modified definition. To facilitate testing, a predefined response was used as a criteria to determine if synthesis had occurred. However, an effort was made to use an analytic technique that would measure any synthetic response, even if not the predetermined one.

Predictions

This experiment deals with the attributes of linearity and meaningfulness, chosen because they are appropriate to both synthesis and multi-media. Linearity refers to temporal occurrences of stimuli manipulated by the simultaneous or consecutive presentation of slides. It tested the assumption that synthesis is more likely to occur between events that are in temporal proximity.

Meaningfulness refers to an intuitively meaningful sequencing of slides and sounds as determined by the experimenter versus a complete randomization of the slides and sounds. This was a control to see if synthesis was facilitated by the density of the material presented, irregardless of any meaningful relationship between the visuals. Also, the underlying structure of the intuitive presentation, if meaningful, could be recovered to determine whether or not synthesis occurred.

The hypotheses were:

1. The multi-screen (non-linear) presentation would elicit more synthetic responses from the Ss than the single screen (linear) presentation.
2. The non-random presentation would elicit synthetic responses that were meaningful in terms of the underlying conceptual structure of the presentations.

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Chapter II

METHOD

Design

The multi-media presentation was varied on two attributes

Linearity: Linear (L) - Non-Linear (NL)

Meaningfulness: Random (R) - Non-Random (NR)

Linearity was manipulated by presenting the visuals either simultaneously or consecutively. In the linear presentation, slides were presented on one screen, one after another. In the non-linear presentation, three screens were used, and as many as three slides presented simultaneously.

Meaningfulness was manipulated by intuitively grouping the slides according to the meaningfulness or non-meaningfulness of the groupings. In the non-random presentations the slides were presented in an order felt by the experimenter to be intuitively meaningful given the subject matter. In the random presentation, the slides were presented in an entirely random order.

A 2 x 2 design with two levels of linearity (simultaneous versus consecutive presentation) and two levels of meaningfulness (intuitive versus random) was used. In addition, a control group received the testing device without any exposure to the multi-media presentation to determine whether the testing device itself generated synthetic responses.

The Dependent Variable was the ability to synthesize as measured by a Similarities Judgment Task and a Sorting Task (Anglin, 1970).

Subjects

The subjects were 95 fifth graders from three different elementary schools from a small town outside of Madison, Wisconsin. They were randomly assigned to the four experimental conditions and the one control group.

Apparatus

The apparatus consisted of three Kodak Carousel projectors, a Wollensak synchronizer (consisting in part of a two-track cassette recorder) which was used to time the presentation of the slides as well as present the audio portion of the display, and a "magic box" (consisting of three relays) which adapted the synchronizer so it could simultaneously advance all three projectors in the Non-Linear conditions.[1] A set of headphones were also used to present the audio portion of the display to minimize extraneous noise.

The slides were all 35 mm Kodachrome II Type A or 35 mm Plus X, photocopied from textbooks, periodicals, etc. (See Appendix A for list of credits.)

The slides were projected onto an off-white wall, to an approximate size of 2' x 1', in a darkened room.

Preparation of the Display

A subject matter was chosen for the topic of the presentation. To enable the experimenter to choose the visuals and sounds in a

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[1] Special thanks are due to John McFee who made the special equipment for this study.

meaningful way, the topic was analyzed and broken down into sub-categories. Sounds and visuals were then chosen to represent these sub-categories.

From the total number of slides and sounds, a three-screened presentation was designed which was felt by the experimenter to have a meaningful structure in the ordering of the slides and sounds. From this original presentation Non-Random:Non-Linear (NR:NL) the other three presentations Non-Random:Linear (NR:L), Random:Non-Linear (R:NL), Random:Linear (R:L) were derived by randomizing the visuals and sounds and/or presenting them sequentially on one screen.

The presentations were shown to the Ss, who were then given a sorting task to see what dimensions of the presentation could be recovered.

The multi-media presentation was on the topic of WATER. This topic was chosen because of the broadness of the topic and relatively easy access to pictures and sounds. To choose the slides and sounds, WATER was divided into 16 descriptive categories organized in two dimensions according to the Figure 1. On the first dimension, five attributes of WATER were defined: physical attributes, life giving qualities, energy, destructive forces, and recreative functions. A second dimension represented the solid, liquid, and gaseous states of water. A sixth attribute, "without water," was subdivided into 'absence of water' and 'pollution.' There were appropriate sounds with each category except the two "without water" categories. The category of "Recreation-Gas" was empty due to the inability to find visual representation of this category. There was a total of 94 slides and eight sounds.

		SLIDES: Solid	SLIDES: Liquid	SLIDES: Gas	SOUNDS
Physical	Attributes	3	4	3	1
Functional	Life Giving	8	14	8	2
	Energy	4	4	4	2
	Destruction	4	4	4	2
	Recreation	8	8		1

	Absence of Water	Pollution
Without Water	9	5

Figure 1 The number of slides and sounds representing each of the 16 categories of WATER

For the testing device (to be described later), one picture and one sound from each category that had multiple examples was randomly chosen. The remaining 78 slides and 5 sounds were then used to make the intuitive, non-linear presentation (NR:NL). All other presentations were derived from this one.

The scripts for the presentations are shown in Appendix B. The NR:NL presentation started with a set of slides showing the consequences of a waterless environment (e.g. a slide of parched earth). The slides successively dealt with the physical attributes of water (e.g., ice, water drop, rainbow), the life giving properties of water (e.g., igloo, irrigation, steam engine), water as energy (e.g., glacier, waterfall, geyser), the destructive forces of water (e.g., hail, flood, fog), the recreative functions of water (e.g., skiing, and sailing), and finally

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pollution (e.g., polluted waterway). There were appropriate sounds with each category except for the two that depicted "without water" (absence of water and pollution). Each of the five "with water" categories, except for recreation, had slides representing the three states of water: solid, liquid, and gaseous. In the two non-linear presentations the three different states in each category were shown simultaneously on the three different screens. The NR:NL presentation is diagramed below; A, B, and C refer to the three different projectors, columns represent slides presented simultaneously.

Event:	1	2	3	4	5	7	. . .	
				A	A	A		
	B	B	B	B	B	B		(NR:NL)
				C	C	C		

That is, the presentation starts with the showing of 4 slides, one at a time on one screen, then 3 sets of 3 slides presented simultaneously on three screens, etc. There was a total of 41 events: 19 were singular, 7 were double, and 15 were triple. The presentations for the other three experimental conditions were made by manipulating the events and the slides within the events.

For the NR:L presentation, the events were kept in the same order, but the slides occurring together in an event were presented singularly in a linear fashion. Thus:

Event:	1	2	3	4	5	6	7	. . .	
	B	B	B	B	ABC	ABC	ABC		(NR:L)

For the R:NL presentation, the events of the original presentation (NR:NL) were randomly mixed with use of a table of random numbers. This randomness of the original 41 events explains the non-sequential ordering of the events in the following key:

Events:	10	22	24	37	28	9	3	. . .	
	A	A	A	A	A				
	B	B	B			B	B		(R:NL)
	C	C	C	C	C				

That is, the presentation starts with 3 sets of 3 slides (the 3 slides within each event being presented simultaneously), followed by 2 events where only two screens are used (the two end screens), and is next followed by 2 events where only one slide at a time is shown (on the middle screen), etc.

The R:L presentation consisted of presentation R:NL presented linearly.

Events:	10	22	24	37	28	9	3	. . .	
	ABC	ABC	ABC	AC	AC	B	B		(R:L)

The sounds in the two non-random conditions (NR:NL and NR:L) were the same since only one sound was heard at a time. For the two random conditions (R:NL and R:L) the sounds were randomized independently of the slides.

To keep the total length of the presentations consistent in all conditions, each slide was shown for 4 seconds. If an event consisted of one slide it lasted 4 seconds on the screen; if it consisted of three slides it lasted 12 seconds on the screen. The total length of all presentations was 4.8 minutes.

Measurements

Three separate tests were administered after the slide presentation to evaluate the effects of linearity and randomness. These tests consisted of 16 pictures representing the 16 descriptive categories of WATER and three sounds. One picture was chosen randomly from each category of the 5 x 3 array of the attributes and states of water. Three sounds were also randomly chosen. The content of the test pictures and sounds are listed in Figure 2 (Appendix C). The 16 pictures were 3" x 5"; eight of the pictures were in color, eight were in black and white.

1. Similarity Judgments. The first test given was a Similarity Judgment Task (Anglin, 1970). The subject is presented with pairs of stimuli which he rates in their degree of similarity to each other. The form of the test used consisted of the presentation of all possible pairs of the 16 pictures (120 pairs) to the subject. Each pair was presented for three seconds. A subject was first told that he was going to be shown a number of pictures, two at a time. He was to look at the two pictures and to decide whether he thought they were very similar, very much alike, related to each other; or very different, not at all alike, unrelated to each other. He was given an answer sheet (Appendix D) that had on it a 7 point scale for each of the 120 pairs. The subject was instructed to circle "1" if he thought the pair was very similar, "7" if he thought it was very different, or any number in between which he thought explained the relationship between the two pictures. The 120 pairs were presented in six different random orders.

2. Sorting Task. This task was also patterned after Anglin (1970). The test used the same 16 pictures as well as the three sounds. The three sounds were presented on a cassette tape. The S listened to each sound for ten seconds and marked a word(s) or drew a

		PICTURES			SOUNDS
		Solid	Liquid	Gas	
Physical	Attributes	snowflake	water drop	mist	
Functional	Life Giving	boy eating "slush"	flooded rice paddy	steam kettle	#1 ocean
	Energy	avalanche	water mill	geyser	#3 steam train
	Destruction	hail	hurricane	light-ning	#2 Niagra Falls
	Recreation	ice figures	diver		

	Absence of water	Pollution
Without Water	dead camel	pollution sign

Figure 2 Pictures and Sounds representing the sub-categories of WATER that were used in the Similarity Judgment and Sorting Tasks.

picture on each of three 3" x 5" index cards to help him remember the sounds. The three index cards were mixed with the 16 pictures and the stack was handed to the S with the instructions to sort them into piles. The S was told he could sort all the cards into one pile, each card into a pile by itself, or anything in between. Afterwards, the S was asked to explain the rationale behind each pile sorted, and the responses were recorded.

3. Questionnaire. Each S was asked five questions.

   1. How many main ideas (or subjects, or topics) did you think were in the presentation?

1.

   A. 1

   B. 2 or 3

   C. More than 3.

2. What do you think they were?

3. Which one was the most important?

4. Was there anything you especially liked about the presentation?

5. Anything you disliked?

Method of Analysis

An Analysis of Variance was performed on the Sorting Task data. It was generally hypothesized that if the experimental technique was effective and multi-media did facilitate synthesis of the predefined concept of water, then the Ss in the NR:NL and R:NL groups should have sorted into fewer piles. If the non-random presentation was meaningful, then the Ss in the NR:NL and NR:L groups should have sorted piles on the basis of WATER characteristics rather than irrelevant characteristics as determined by their explanations of the piles. The expected results were more specifically stated in the following five hypotheses:

1. The Number of Sorts: It was expected that fewer piles would be sorted for the non-linear versus the linear groups.
2. Size of Water Sort: It was expected that since the overall subject was water, success of synthesis would be manifested in a large "water sort" for the non-random groups versus the random groups.

3. 6 Dependent Variables: Attributes, Life Giving, Energy, Destruction, Recreation, & Without Water: Each of the five dimensions had three examples. If a S sorted all three examples in the same pile he received a score of 100%. If he sorted only two together, he received 66%, etc. These proportional scores were analyzed to see if the dimensions could be recovered. It was expected that they would be more recoverable in the non-random and non-linear conditions than in the random and linear conditions.

4. 3 Dependent Variables: Solid, Liquid, Gas: Each of the three states had 5 examples. These were scored and analyzed proportionally as with the five dimensions. It was expected that the states would be recoverable in the non-random versus random conditions, and the non-linear versus linear conditions

Two sets of orthogonal relationships were analyzed on all five hypotheses.

1. - Overall
   - Experimental groups (NR:NL, NR:L, R:NL, R:L) versus Control
   - Hypothesized Best Group (NR:NL) versus others (NR:L, R:NL, R:L, Control)

2. - Random groups (R:NL, R:L) versus Non-Random groups (NR:NL, NR:L)
   - Non-Linear groups (NR:NL, R:NL) versus Linear groups (NR:L, R:L) and Interaction.

Both the Similarity Judgment and Sorting Tasks were analyzed with use of Hierarchical Clustering Schemes (Johnson, 1967) (HICLUS). The input of this program, is a lower half matrix of the number of Ss who sorted each set of two stimuli together. There is one matrix for each of the five groups. The output gives the number of Ss who sorted each pair together, which can then be diagramatically represented by hierarchical tree clusters. It was expected that there would be fewer, more complex clusters for the non-linear versus linear groups. It was further hypothesized that there would be a major "water cluster" for the non-random versus random groups.

Both the Similarity Judgment and Sorting Tasks were also analyzed with MDSCAL (Shepard, 1964). This is a multidimensional scaling technique to analyze a matrix when the underlying dimensions are unknown. The input data are in the form of a lower half matrix. There is one matrix for each of the five conditions which is a matrix of means (similarity of judgments, etc.) for the responses of each of the individual subjects within that condition.

For the Sorting Task, the matrices were derived by tallying the number of Ss within each condition who paired any two pictures and/or sounds together. For the Similarity Judgment Task the matrices were derived by averaging the ratings across Ss for each of the 120 pairs for each group.

Finally, the Similarity Judgment and Sorting Tasks were analyzed with INDSCAL (Carroll & Wish, 1970). This is also a multidimensional technique which can handle individual differences. For this analysis each S's individual matrix was used.

Chapter III

RESULTS

Analysis of Variance

An ANOVA was performed on the Sorting Task Data for two sets of orthogonal relationships on 4 hypotheses as noted in Chapter II: number of sorts, water sort, 6 dependent variables (Attributes, Life Giving, Energy, Destruction, Recreation, Without Water), 3 dependent variables (Solid, Liquid, Gas). All Fs proved to be non-significant (See Table 1 and Table 2).

HICLUS

Agreement in clusterings between Ss for both the Similarity Judgment and Sorting Tasks is shown in Table 3. This agreement reached a high of 78.9% of the Ss in the Sorting Task, while only 36.0% of the Ss in the Similarity Judgment Task.

The Hierarchical Clusterings for the Sorting Task data are diagramatically shown in Figures 3-7. The scale on the vertical axis is the number of Ss out of a total of 19 in each group that clustered the various pictures and/or sounds together. It is read at the node where two or more pictures and/or sounds intersect. These results will be thoroughly discussed in the next chapter. The Similarity Judgment Task data, due to their unreliability, is not included (to be discussed later).

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Table 1

MEAN PROPORTIONS AND STANDARD DEVIATIONS OF VARIABLES AS A FUNCTION OF GROUP

	Average of Number Sorts	Average "Water" Sort	Attributes*	Life Giving*	Energy*	Destruction*	Recreation*	Without Water*	Solid*	Liquid*	Gas*
Group 1: NR:NL											
Mean	6.42	7.21	.66	.56	.66	.54	.63	.71	.48	.64	.57
SD	2.89	4.71	.22	.25	.27	.20	.28	.25	.17	.28	.23
Group 2: NR:L											
Mean	5.95	5.21	.63	.50	.61	.54	.55	.68	.51	.63	.57
SD	2.46	4.87	.22	.20	.23	.20	.16	.25	.17	.22	.16
Group 3: R:NL											
Mean	5.21	5.58	.68	.59	.68	.56	.61	.63	.48	.68	.63
SD	2.35	4.71	.21	.24	.24	.22	.21	.23	.17	.18	.19
Group 4: R:L											
Mean	6.21	5.89	.63	.52	.59	.65	.58	.69	.46	.72	.54
SD	2.18	3.91	.22	.17	.18	.26	.19	.27	.20	.19	.15
Group 5: C											
Mean	5.16	5.42	.75	.64	.63	.52	.66	.66	.46	.71	.57
SD	2.09	4.89	.25	.21	.19	.20	.24	.24	.15	.25	.20

* Proportional Scores

Table 2

MULTIVARIATE AND UNIVARIATE ANALYSIS OF VARIANCE
FOR THE SORTING DATA

	Univariate Analysis					Multivariate Analysis*		
Source - Groups	MS	F	df	Prob	Source - Variables	F	df	Prob
Groups			4,90					
ψ_1 Exper. vs. Control	9.47	1.63	1,90	<.205	Number of Sorts			
	4.64	.22	1,90	<.643	Water Sort			
					6 Dependent Variables	1.77	6,85	<.155
	.16	3.17	1,90	<.079	Attributes			
	.15	3.31	1,90	<.072	Life Giving			
	.00	.03	1,90	<.869	Energy			
	.04	.75	1,90	<.389	Destruction			
	.06	1.35	1,90	<.249	Recreation			
	.00	.06	1,90	<.804	Without Water			
					3 Dependent Variables	.28	3,88	<.840
	.01	.23	1,90	<.634	Solid			
	.02	.39	1,90	<.532	Liquid			
	.00	.05	1,90	<.820	Gas			

* Compared mean vectors across variables.

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Table 2 (cont.)

	Univariate Analysis					Multivariate Analysis		
Source - Groups	MS	F	df	Prob	Source - Variables	F	df	Prob
ψ_2 Randomness	4.26	.73	1,90	<.394	Number of Sorts			
	4.26	.20	1,90	<.657	Water Sort			
					6 Dependent Variables	.412	6,85	<.864
	.00	.03	1,90	<.866	Attributes			
	.01	.27	1,90	<.603	Life Giving			
	.00	.00	1,90	<.992	Energy			
	.07	1.54	1,90	<.217	Destruction			
	.00	.00	1,90	<.979	Recreation			
	.04	.70	1,90	<.406	Without Water			
					3 Dependent Variables	.683	3,88	<.565
	.01	.29	1,90	<.594	Solid			
	.08	1.45	1,90	<.232	Liquid			
	.01	.26	1,90	<.610	Gas			

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Table 2 (cont.)

	Univariate Analysis					Multivariate Analysis		
Source - Groups	MS	F	df	Prob	Source - Variables	F	df	Prob
ψ_3 Linear								
ψ_4 Interaction	5.82	1.00	2,90	<.371	Number of Sorts			
	19.47	.91	2,90	<.407	Water Sort			
					6 Dependent Variables	.52	12,170	<.898
	.02	.38	2,90	<.685	Attributes			
	.04	.81	2,90	<.450	Life Giving			
	.05	1.02	2,90	<.366	Energy			
	.04	.78	2,90	<.461	Destruction			
	.03	.73	2,90	<.485	Recreation			
	.00	.16	2,90	<.853	Without Water			
					3 Dependent Variables	.48	6,176	<.821
	.00	.14	2,90	<.867	Solid			
	.01	.10	2,90	<.904	Liquid			
	.04	.99	2,90	<.377	Gas			

Table 3

HIGHEST PERCENTAGE OF Ss WHO CLUSTERED ANY
TWO PICTURES AND/OR SOUNDS TOGETHER

	Sorting Task	Similarity Judgment
NR:NL	78.9%	34.6%
NR:L	78.9%	35.2%
R:NL	68.4%	34.4%
R:L	73.7%	35.5%
C	78.9%	36.0%

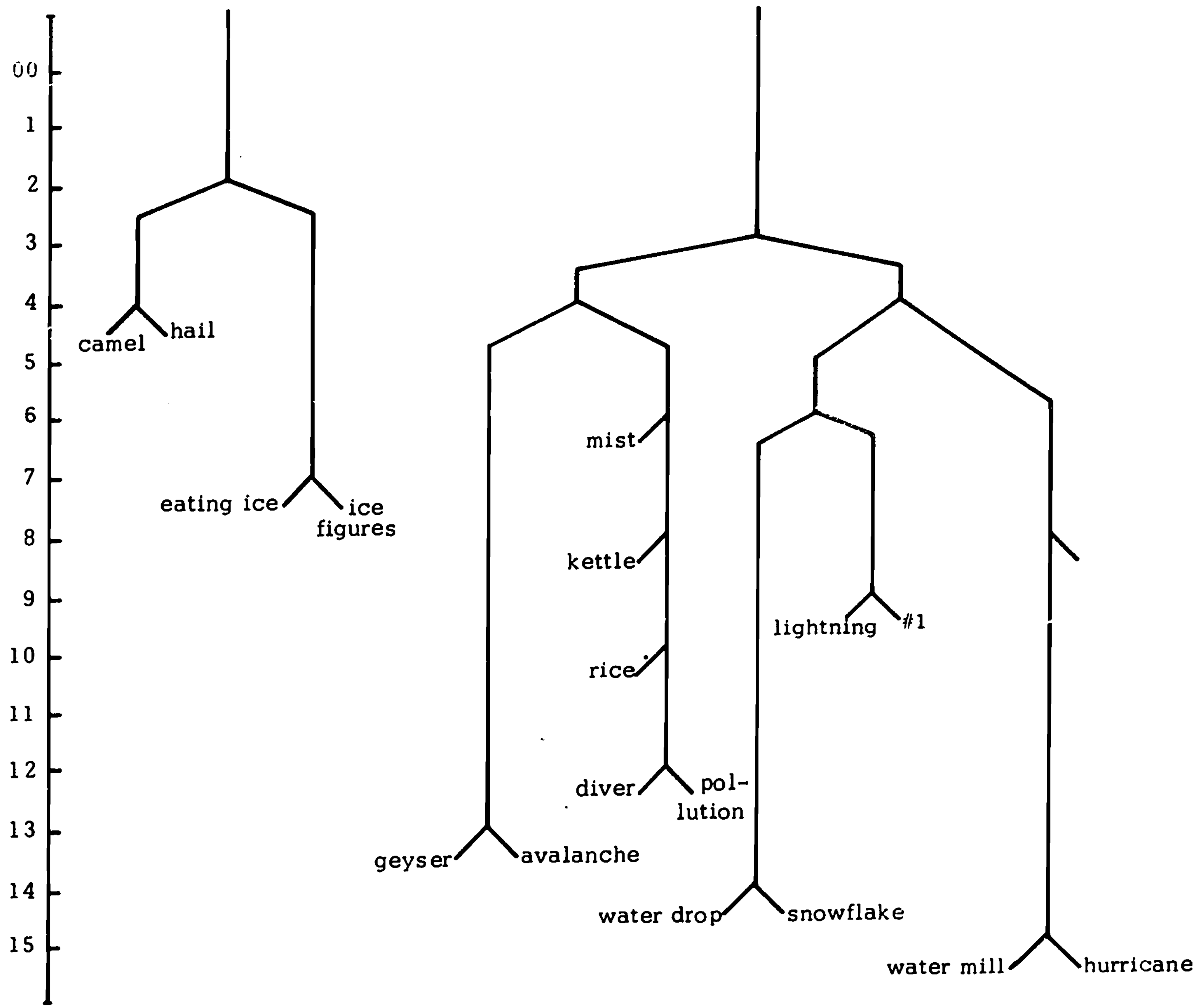

Figure 3 Hic hical Clustering of NR:NL Group-Sorting Task

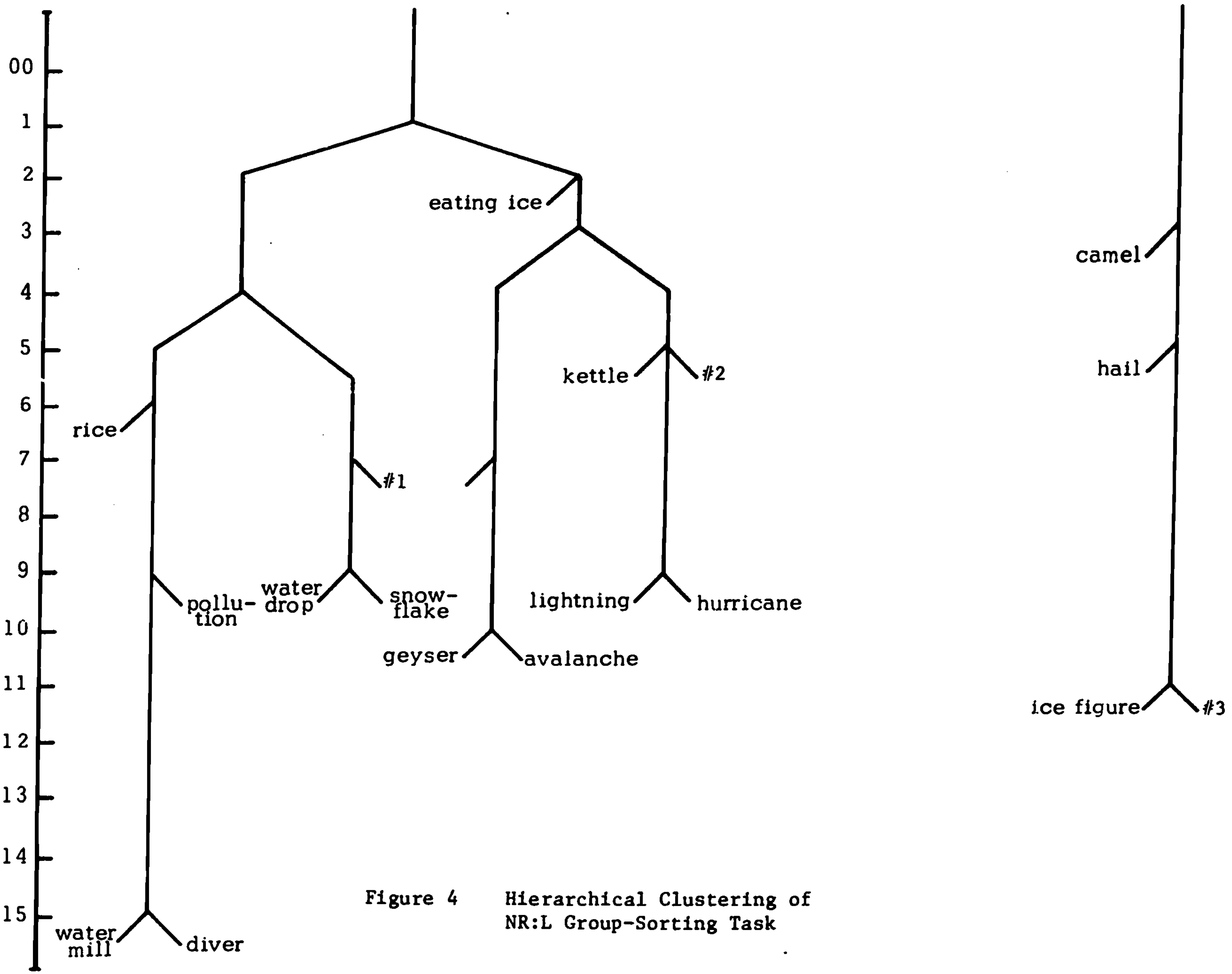

Figure 4 Hierarchical Clustering of NR:L Group-Sorting Task

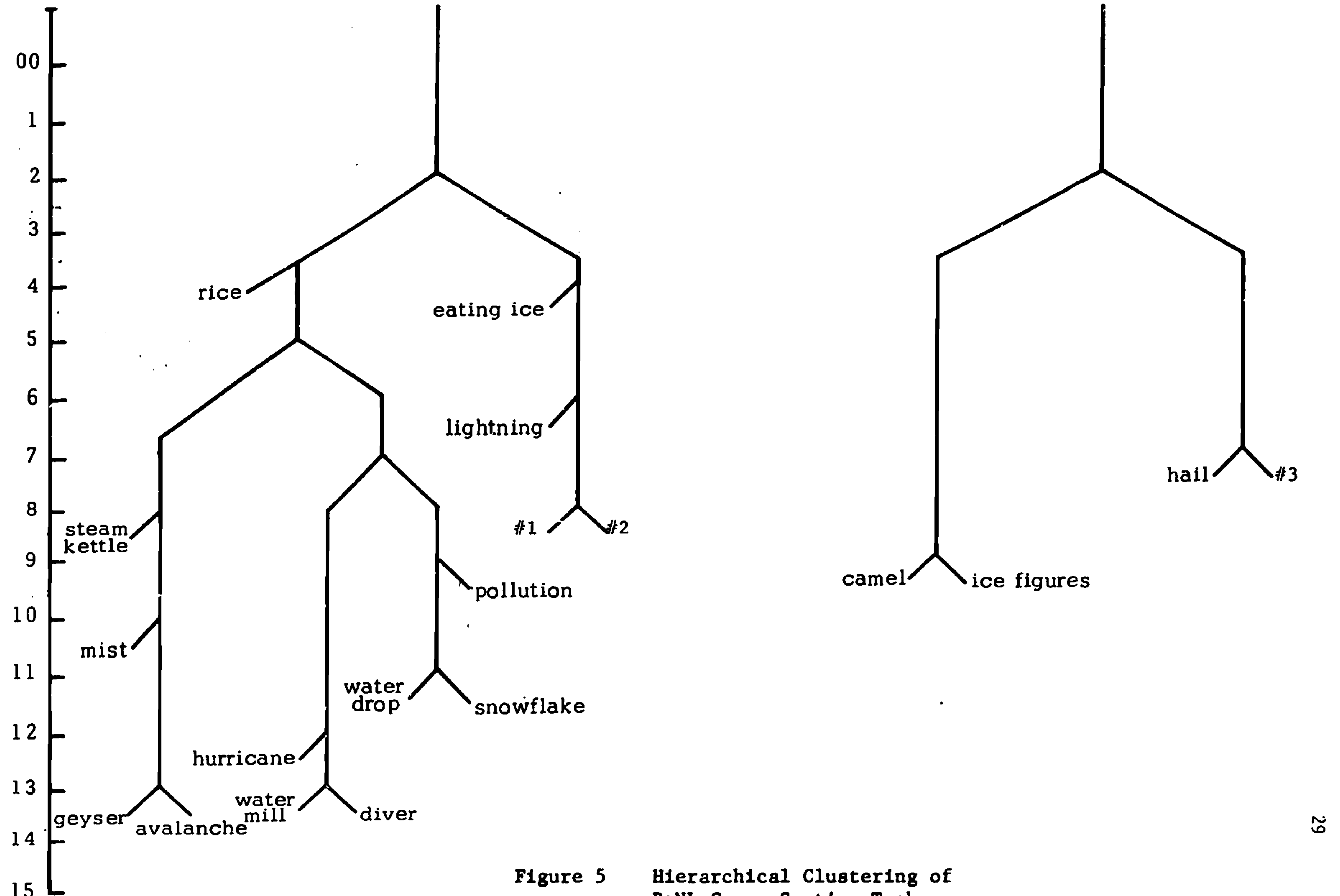

Figure 5 Hierarchical Clustering of R:NL Group-Sorting Task

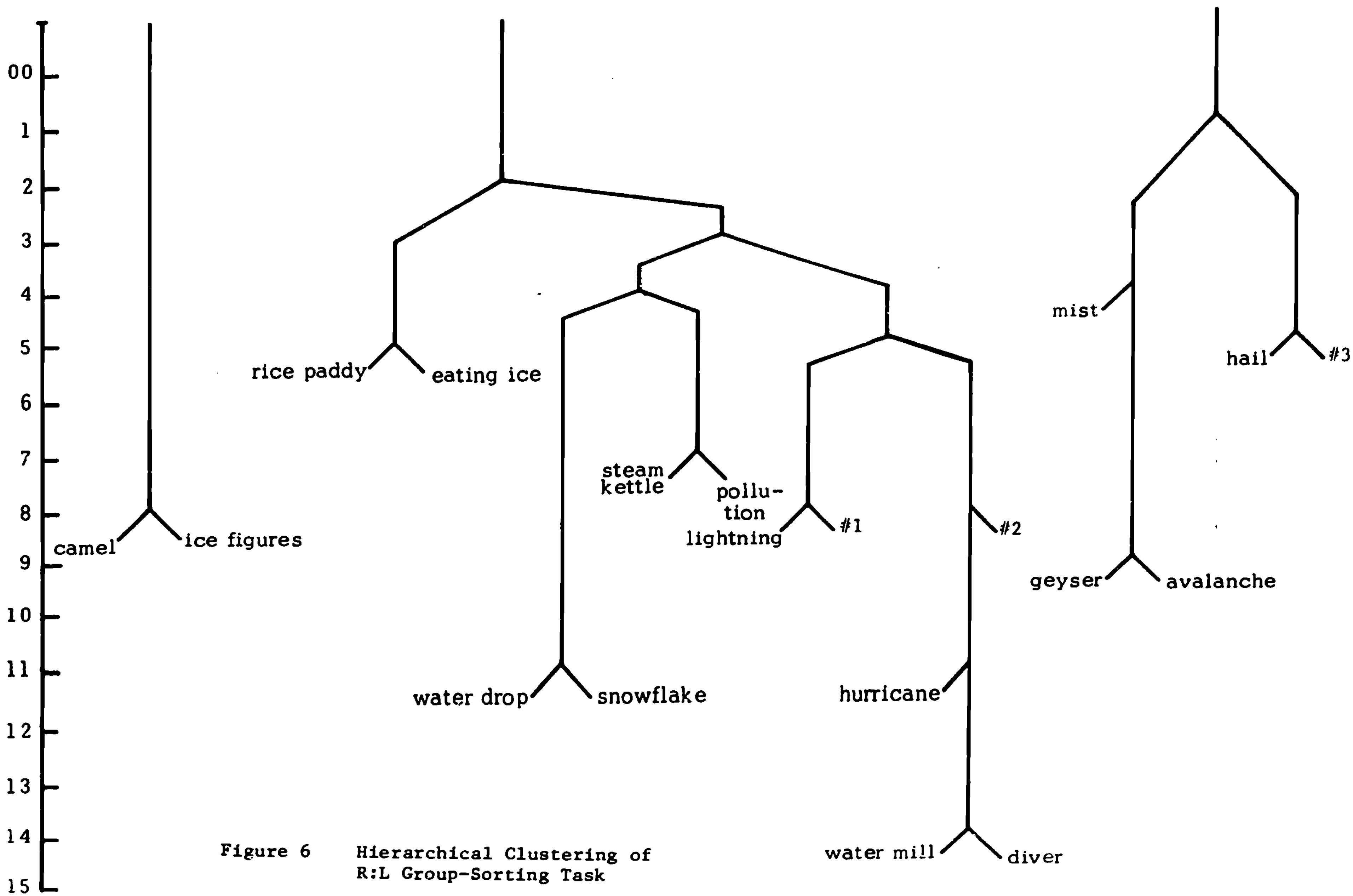

Figure 6 Hierarchical Clustering of R:L Group-Sorting Task

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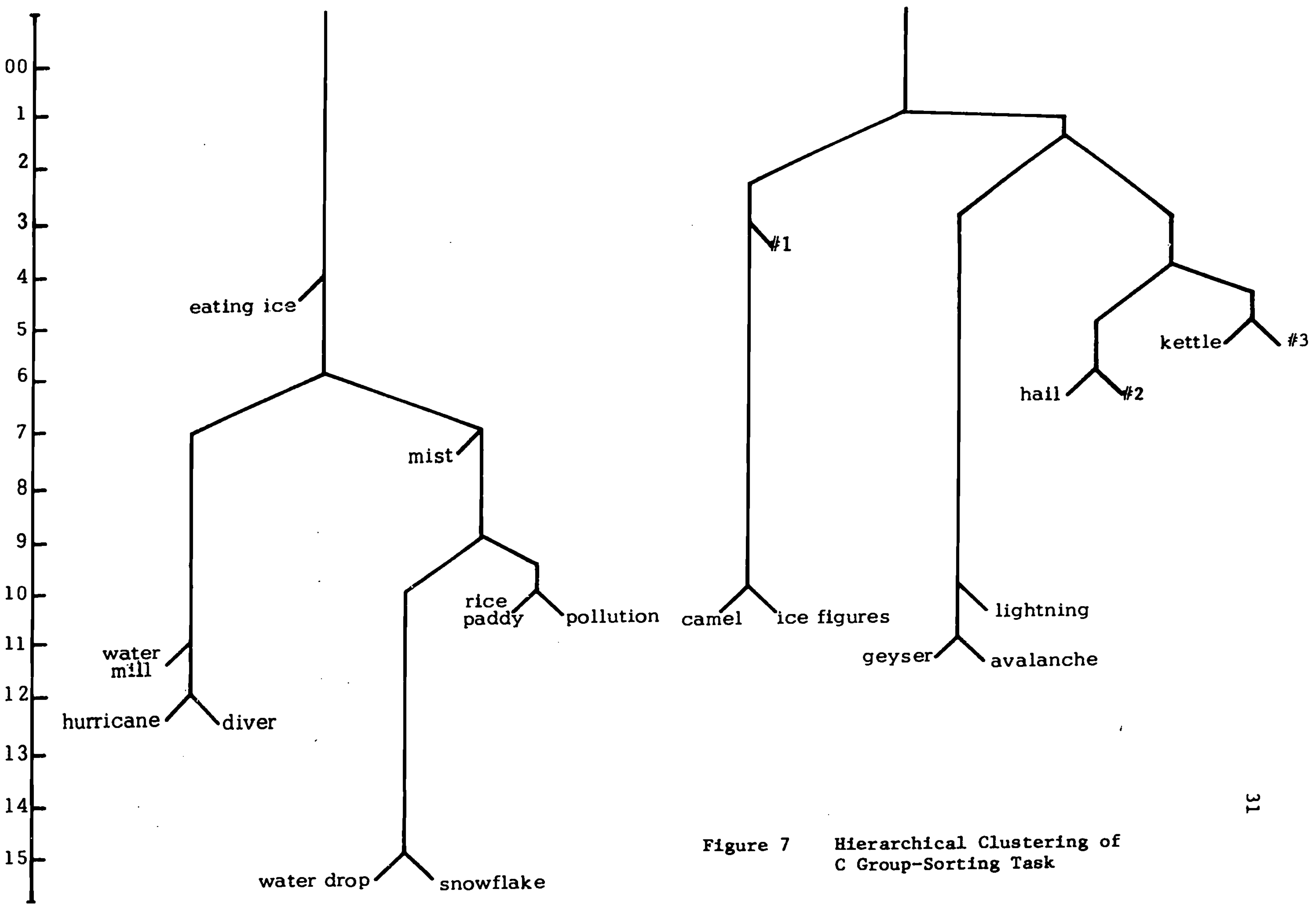

Figure 7 Hierarchical Clustering of C Group-Sorting Task

MDSCAL

The stress levels as generated by MDSCAL for the Similarity Judgment and Sorting data are shown in Table 4. The closer the stress level approaches .000, the more of an indication that the underlying dimensions are appearing. Thus the 4-dimensional model is more appropriate because it has a lower stress level than the other models. But the fact that it hasn't yet reached the .000 level is an indication that even a more complex model might be more appropriate. The difficulty in interpretation, however, prevented further analysis. The Sorting Task had a much lower stress level than the Similarity Judgment Task; .164 (NR:NL) for the Sorting Task versus .509 (NR:L) for the Similarity Judgment Task.

The data were analyzed on 4, 3, 2, and 1 dimensions in an attempt to find an appropriate model. The position of each stimulus on the four different models are shown in Appendix E. The 3-D for the NR:NL, R:L, and C groups are shown in Figures 8-10. Once again, it should be noted that the Sorting Task data have more interpretability, and is similar in its spacial configurations to the HICLUS diagrams.

INDSCAL

The loadings of the stimuli on the three-dimensional models generated by INDSCAL are shown in Appendix F. As can be seen, all Ss in all groups are in the same quadrant. These results show homogeneity in the Ss' perceptions of the stimuli and will be thoroughly discussed in the next chapter.

Table 4

STRESS LEVEL OF MODELS DERIVED BY MDSCAL FOR ALL GROUPS
IN SORTING TASK AND SIMILARITY JUDGMENT TASK

	Sorting Task				Similarity Judgment Task			
	4-D	3-D	2-D	1-D	4-D	3-D	2-D	1-D
NR:NL	.164	.205	.274	.442	.589	.649	.728	.805
NR:L	.251	.317	.387	.521	.509	.568	.681	.759
R:NL	.221	.286	.345	.635	.563	.624	.705	.817
R:L	.233	.330	.440	.501	.554	.612	.651	.744
C	.190	.272	.358	.539	.524	.601	.692	.809

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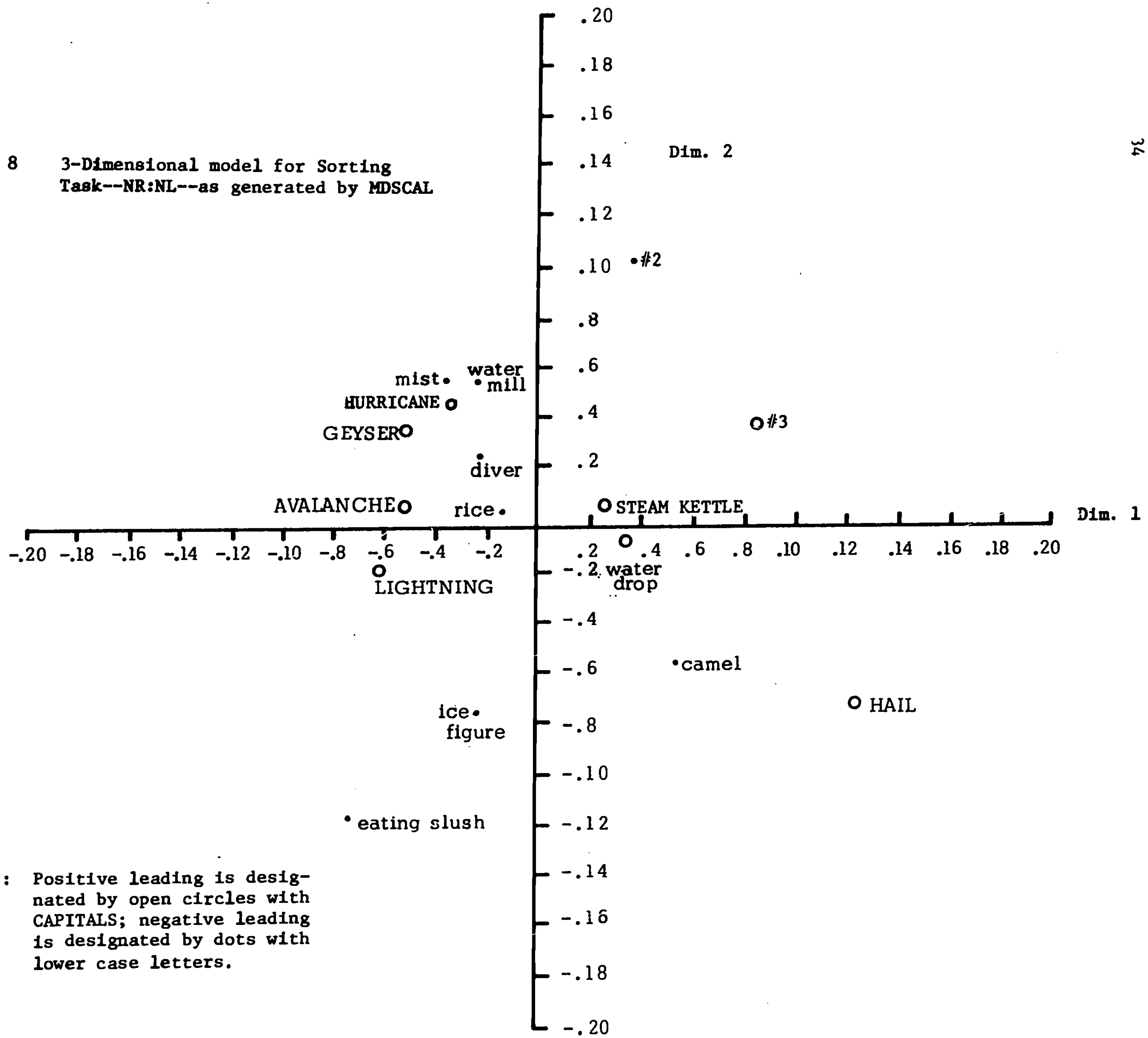
Figure 8 3-Dimensional model for Sorting Task--NR:NL--as generated by MDSCAL



Dim. 3: Positive leading is designated by open circles with CAPITALS; negative leading is designated by dots with lower case letters.

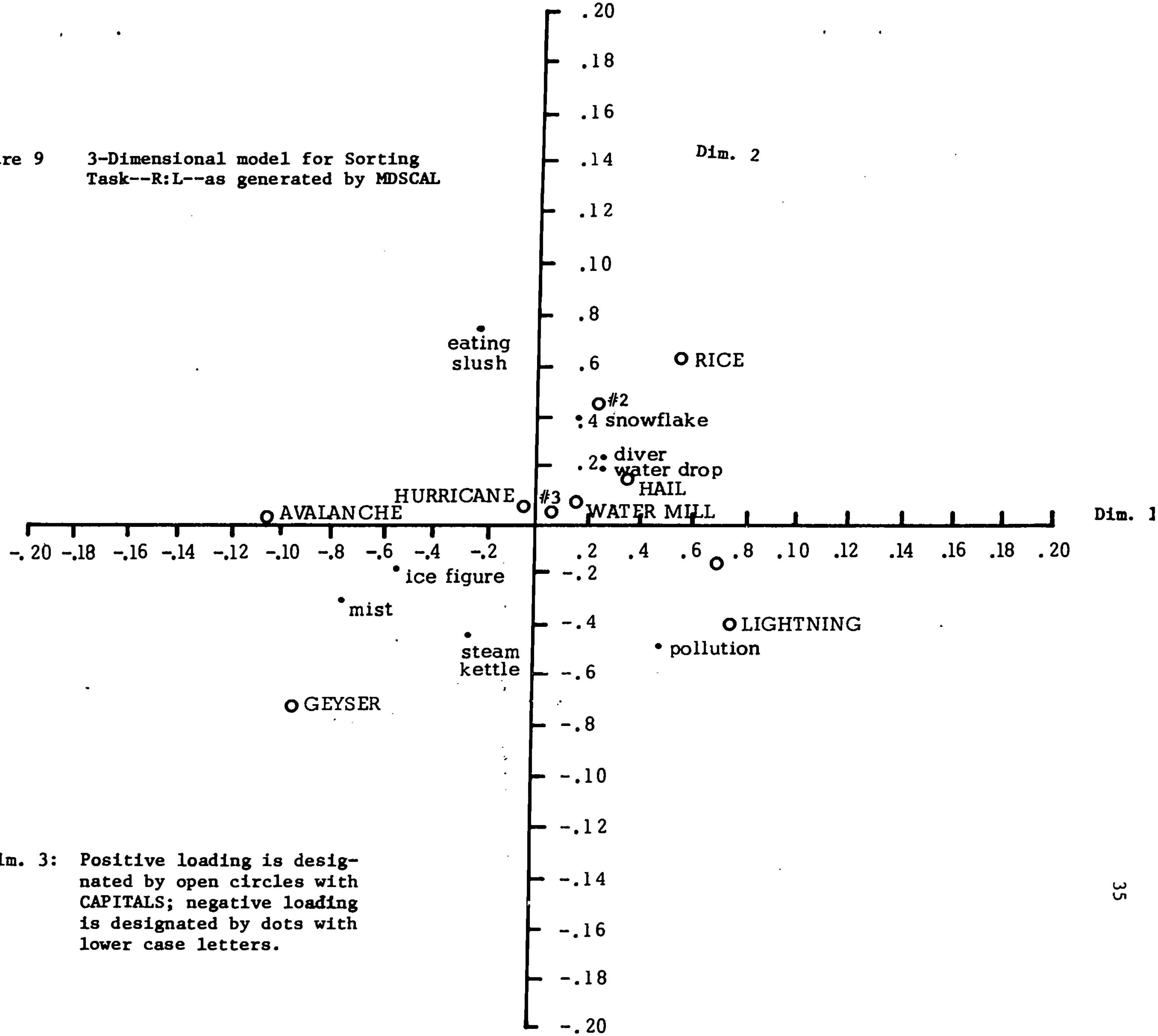
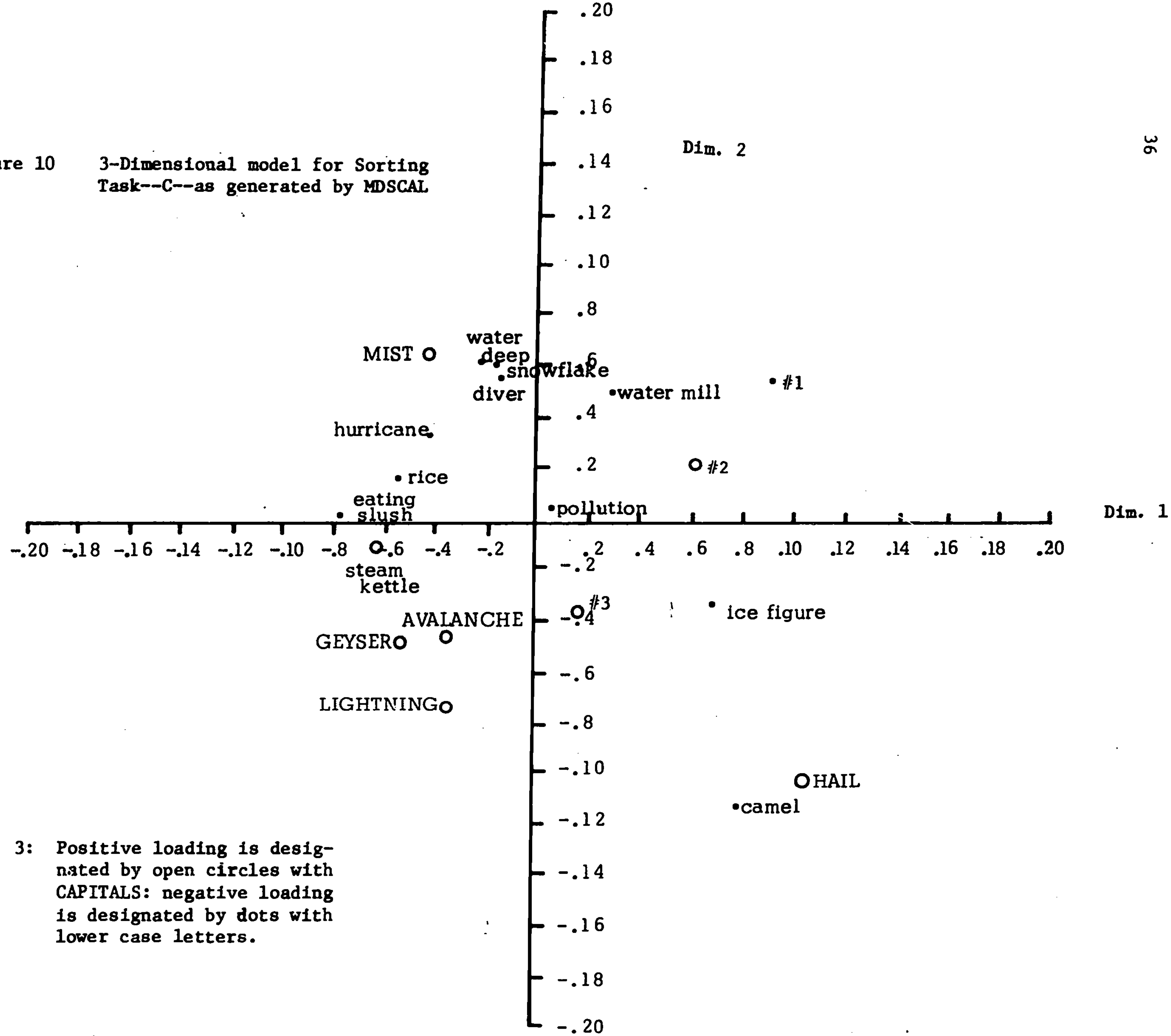


Figure 9 3-Dimensional model for Sorting Task--R:L--as generated by MDSCAL

Dim. 3: Positive loading is designated by open circles with CAPITALS; negative loading is designated by dots with lower case letters.

Figure 10 3-Dimensional model for Sorting Task--C--as generated by MDSCAL



Dim. 3: Positive loading is designated by open circles with CAPITALS: negative loading is designated by dots with lower case letters.

Chi-Square

A chi-square was performed on the three questions asked of each S at the end of the testing session. The results are shown in Table 5. As can be seen, only two of the chi-squares proved significant.

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Table 5

RESULTS OF THE CHI-SQUARE PERFORMED ON THE QUESTIONNAIRE DATA

Question	Variable	df	X^2	
1a. Perceived only one main topic on the presentation.	NR vs. R	1	2.29	N.S.
	NL vs. L	1	2.90	N.S.
1b. Perceived 2 or 3 main topics on the presentation.	NR vs. R	1	1.92	N.S.
	NL vs. L	1	0.82	N.S.
1c. Perceived more than 3 main topics on the presentation.	NR vs. R	1	4.65	P <.05*
	NL vs. L	1	0.06	N.S.
2. Perceived that water was a main topic.	NR vs. R	1	5.65	P <.05*
	NL vs. L	1	0.23	N.S.
	Interaction	3	0.00	N.S.
3. Perceived that water was the most important topic.	NR vs. R	1	2.26	N.S.
	NL vs. L	1	1.34	N.S.
	Interaction	3	0.08	N.S.

*X^2 (1 df) - 6.64 P <.01

X^2 (1 df) - 3.84 P <.05

Chapter IV

DISCUSSION

The Sorting Task data were also analyzed by ANOVA. None of the hypotheses showed significance. A possible explanation is the experimental design. The way in which the Randomness variable was operationally defined might have been a factor in the lack of significance of the analysis of variance. In the experiment, the ordering of the events was randomized while the slides within these events remained constant. Since the slides in each event were related, the presentation was not thoroughly randomized. The Randomness variable could have been better manipulated by keeping a constant structure (e.g., B B B $\begin{smallmatrix}A\\B\\C\end{smallmatrix}$ . . .), while randomizing all of the total number of slides within this structure. The kinds of events were also poorly controlled. Of the 41 events, 19 were singular, 7 were double, and only 15 were triple. The large number of singular events might have made the non-linear conditions less non-linear than expected.

Each of the two test measures (Sorting Task and Similarity Judgment Task) was analyzed with use of HICLUS, MDSCAL, and INDSCAL. Trends throughout the analysis were strong enough to suggest that the Similarity Judgment Task was unreliable. In the HICLUS analysis agreement in sorting pictures together reached a high of 78.9% of the Ss, whereas with the Similarity Judgment Task, this percentage never reached a level higher than 36.0%.

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Similarly with MDSCAL, the stress in the Sorting Task data was as low as .164 for the four-dimensional model of the NR:NL group. The groups with the lowest stress level in the Similarity Judgment Task (NR:L) still had a stress level of .509 for the four-dimensional model after 30 iterations. This poor convergence of the Similarity Judgment data reinforces what the HICLUS analysis suggests--the Similarity Judgment Task was not a reliable one.

The higher reliability of the Sorting Task over the Similarity Judgment Task, might be interpreted in terms of the nature of the tasks themselves or the order in which they are presented. In the Similarity Judgment Task, the S saw only two stimuli at a time. With only two stimuli it is reasonable to assume that there would be more variance in the dimensions used by the Ss to judge the similarity of the stimuli, than in the Sorting Task, where the S was presented all 19 stimuli simultaneously. In the Sorting Task a S could judge only similar or not similar (Sort into the same pile or sort into different piles.). In the Similarity Judgment Task, the S could judge similarity of the pictures on a much more sensitive scale. Forcing the S to make an "either-or" decision, and presenting an overall view of the stimuli, might explain the differences in reliability between the Sorting and Similarity Judgment Tasks.

Another possible explanation is that the Similarity Judgment Task was given first in all cases. The nature of the task permitted the S to experiment with many ways for judging similarities, and thus he approached the Sorting Task as a more sophisticated testee.

Although the descriptive analysis suggest trends, they are not strong enough to ensure a definitive interpretation. The lack of results in these analyses might be a result of the complexity of the pictures and sounds used in both the presentations and measurement devices. The pictures chosen were deliberately complex to allow the S to synthesize different concepts than the pre-determined one. What was gained in flexibility was lost on control. For example, the picture representing the "solid-recreation" sub-category of WATER depicted snow sculptures in the shape of dinosaurs. Approximately half of the Ss described the pile they sorted this picture into as "dead animals," while the other half sorted it into a WATER pile. There were too many variables to allow recovery of the predefined concept.

The sounds were also poorly chosen. Playing the sounds without identification prevented the experimenter from imposing her own labeling on the S. But this method was not successful because the sounds were too difficult to identify. Very few Ss were able to recognize the first two sounds (ocean and waterfall), and the third sound (steam train) was easy to identify, but not recognizable as "steam."

The poor choice of slides and sounds is further evidenced by the results of INDSCAL. The homogeneity in the Ss' perceptions of the stimuli suggests that the attributes were either so salient they evoked similar responses, or so complex that each S interpreted them differently. The former is believed to be true on the basis of the HICLUS analysis which showed unexpected similarities between the clusterings of the experimental groups.

HICLUS, MDSCAL, and INDSCAL all attempt to discover underlying structures of psychological judgments. Since each focuses on a different perspective of the data, one method might be more appropriate than another.

> Sometimes interpretation cannot be accomplished in a strictly "dimensional" way, but rather, involves isolating important clusters of stimuli that form contiguous "neighborhoods" in the multidimensional space. This "cluster approach to interpretation is frequently enhanced by use of the 'hierarchical clustering' method . . ." (Carroll & Wish, p. 9-10).

The HICLUS diagrams, interpreted by the descriptions of the piles sorted, suggested differences between the groups. The most prominent difference was between the Experimental groups and the Control group. There is an obvious qualitative difference between the respective graphs. The Control groups clustered the 19 stimuli into two equal clusters. On the basis of the Ss' sorting explanations, the two clusters were labeled "WATER" and "danger" ("bad things"). These two main clusters were present in the four Experimental groups, but in different proportions (the "WATER" cluster being very large, the "danger" cluster being very small). An example is the two pictures of an "avalanche" and a "geyser," which in all clustering schemes were clustered together. However, in the NR:NL group they were clustered under the "WATER" category; in the R:L and the Control groups, they were clustered under the "danger" category. While trends such as this were few in the present data, they suggest that improvements in design might result in more marked differences in synthesis for the various treatment conditions.

Similar results are suggested with the MDSCAL analysis. The graphs of the three dimensional models for groups NR:NL, R:L, and C are shown in Figures 8-10. Stimuli were clustered similarly in MDSCAL as in HICLUS, but the actual dimensions of MDSCAL were more difficult to label. Each model had at least one dimension of "WATER" versus "non-water," but other dimensions were too variable to permit accurate labeling.

A chi-square performed on the questionnaire asked at the end of the testing session proved non-significant for all but two tests. The significant results showed that the randomness effected the number of topics perceived (greater than three) and the Ss' perception of WATER as the most important topic. This suggests that the non-random presentation was more meaningful than the random one in terms of the Ss' understanding of what was generally being presented. This is an isolated result, however, and cannot be weighed very heavily.

Chapter V

CONCLUSIONS

This experiment studied whether multi-media could facilitate fifth graders' ability to synthesize concepts. Two variables of both multi-media and synthesis, linearity and randomness, were tested. None of the hypotheses proved significant; the results only suggested trends. This experiment was meant as exploratory research in an effort to determine fruitful areas of study within the field. Many criticisms can be made concerning this research with suggestions for further studies.

Synthesis, a highly sophisticated cognitive skill, might be developmental. In this case, fifth graders might be incapable of synthesizing as it was operationally defined. The first step to test this hypothesis would be to replicate the study using adults. Success would indicate that the fault did not lie with the experimental method per se, but with the inability of fifth graders to synthesize.

If multi-media did not facilitate synthesis in adults than a new experimental design must be tested. This design must allow for more control. If the stimuli had fewer dimensional variables there would be fewer possible syntheses, and differences between the Experimental and Control groups might be revealed.

Experimental control could also be accomplished by changing the format of the presentation from a large, complex one to a number of smaller presentations, each presenting one idea. These ideas could then be more closely controlled for linearity versus non-linearity, randomness versus non-randomness, and dissonant versus related concepts. For example, what is the maximum temporality possible between two concepts that will still result in synthesis? How many irrelevant concepts can occur between the concepts to be synthesized without having an adverse effect? Is this number different if the two concepts to be synthesized are related or dissonant?

Another, completely different approach is the testing of synthetic responses in individual multi-media presentations. This had been the traditional approach in research up until now. Monahan in his conclusions suggests that "instruction of a heterogeneous group of students by a single multi-media program is likely to be inefficient and ineffective in terms of some subgroup or subgroups of students." (p.64). The difference between this study and Monahan's was the nature of the dependent variable. There is no valid and reliable test to judge the ability to synthesize. Perhaps, though, individual differences such as verbal ability, or ability to think abstractly, etc., could be correlated with success of multi-media in facilitating synthesis. This would be a way of determining the effectiveness of multi-media on a cognitive skill similar to the way Monahan was able to determine the effectiveness of multi-media with Ss of different mathematical abilities.

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Appendices A through E have been deleted from this paper, but are available on microfilm from Memorial Library, University of Wisconsin, Madison, Wisconsin.

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