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ABSTRACT

In this paper, individuals with no background in cognitive psychology are provided an introduction to the cognitivists' concepts of prototypes, schemata, and superordinate relations. A prototype is a most-typical instance, a composite, or an average of items in a particular set and serves as a mental representation of the set. A schema, script, or story grammar is a sequence of features that typically occur in a common event or story. The term "superordinate relations" refers to "links" between specific concepts and superordinate concepts in a "semantic network." Described in the paper are the kinds of empirical evidence on which these inferred mental entities are based. In addition, possible behavioral interpretations are suggested for prototypes and schemata. The evidence of superordinate relations is considered to be difficult to interpret both behaviorally and cognitively. (RH)

Abstraction of Prototypes, Schemata, and Superordinate Relations

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Abstract

Prototypes, schemata, and superordinate relations are inferred mental entities. This paper provides an introduction to these concepts, written for noncognitivists. A prototype is a most-typical instance, a composite, or an average of items in a particular set and serves as a mental represention of the set. A schema (script, story grammar) is a sequence of features that typically occur in a common event or story. Superordinate relations refer to "links" between specific concepts and superordinate concepts in a "semantic network." The kinds of empirical evidence on which the inferences are based are described in this paper, and for prototypes and schemata possible behavioral interpretations are suggested. The evidence of superordinate relations is hard to interpret behaviorally, but it is also hard to interpret cognitively.

Abstraction of Prototypes, Schemata, and Superordinate Relations

In cognitive psychology, prototypes, schemata, and superordinate relations are inferred mental entities that represent various kinds of abstractions. Although these mentalistic concepts are unlikely to interest behavior analysts, the topics they are intended to refer to and the methods used to study them may be of interest to behavior analysts who are concerned with private events and rule-governed behavior. The general purpose of the present paper is to provide a summary introduction to this area. The paper is intended for readers with little or no background in cognitive psychology.

A prototype represents a category of items, and is abstracted from exemplars of the category; in some theories, a prototype is called a template. I will give examples later. A schema represents a category of events or a category of narratives; schemata for events are also called scripts, and for narratives, scripts or story grammars. Theoretically, they are abstracted from experiences with events or stories. Superordinate relations of the kind I have in mind are hypothesized in semantic network theories of meaning, in which concrete concepts such as shark and salmon are linked to abstract superordinate concepts such as fish and animal.

The specific purposes of the present paper are to summarize some of the empirical evidence on which inferences about prototypes, schemata, and superordinate relations are based, and to discuss behavioral interpretations of the evidence. However, because I have discussed schemata and superordinate relations elsewhere (Reese, in press), I will not discuss them herein in any detail.

Prototypes

A prototype is a model of some sort. For example, if you are asked to think of a sport, you are more likely to think of football than weightlifting; and if you are asked to think of a bird, you are more likely to think of a robin than a chicken (Anderson, 1980, p. 130). In a sense, then, football is a model sport--a prototypical sport--and a robin is a prototypical bird. However, in another sense of "model," a prototype is an ideal type or template. Football and robin are not prototypes in this sense.

Research on Prototypes

Prototypes of the ideal or template sort have been studied experimentally. In a typical study, the researcher uses two or more sets of stimuli, each set consisting of transformations of a single standard stimulus, or prototype. The research participant is familiarized with the sets and is then tested for abstraction of the prototype. In a typical

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Note. A condensed version of this paper was presented in H. W. Reese (Chair), Abstraction and generalization. Symposium conducted at the meeting of the Association for Behavior Analysis, Nashville, TN, May 1987.

experiment, the research participant sorts the stimuli into categories with corrective feedback in the familiarization or training phase. In the test phase, the stimuli to be sorted include some that were sorted in the training phase and some not seen before, including new transformations and the actual prototypes.

Figures 1 and 2 show nonsense shapes used as stimuli by Nedra Reed

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Figures 1 & 2

(1979). The stimulus at the top of each set is the standard, or prototype, and the others are variations created with certain transformation rules. The research participants were 5- and 8-year-olds. In the training phase, each child sorted nine transformations from each set into two categories, continuing to a criterion of no more than one error per set. In the test phase, the child sorted nine items from each set, including three of the transformations that were used in the training phase, three transformations not seen before, and three duplicates of the prototype, which had also not been seen before. Sorting was most accurate for the prototypes and least accurate for the new transformations.

This result is typical and has been obtained in adults as well as children and with various kinds of stimuli. Figure 3 is an example from

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Figure 3

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research with adults. It shows some of the stimuli used by Stephen Reed (1972) in a study with college students. The research participants were shown an array like the one in Figure 3 and were told that the items in the first row were from "Category 1" and the items in the second row were from "Category 2." Then, with the array remaining visible, the research participants were shown (Exp. 2) 24 other faces one at a time and had to classify each one as Category 1 or Category 2. The last four test items were the two prototypes and two control items with features that had the same average similarity to the arrayed category items as the prototypes. Reed found that the prototypes were sorted considerably (and significantly) more accurately than the control items.

Cognitive theorists have assumed that the research participant acquires some kind of mental representation of each category of items. Three groups of theories can be identified (for fuller discussion and references, see Anderson, 1980, chap. 5). (1) In some theories the category is assumed to be represented by a set of representations of individual exemplars, with no summarizing but perhaps with some selectivity. (2) Another view is that the category representation consists of the set of properties of the exemplars. In some versions the properties are weighted by the frequency of their occurrence in the exemplars. (3) A third view is that the category is represented by a prototype, a single representation that is most similar to all the exemplars in the category. At least three versions of the third view--that is, prototype theories properly so-called--have been proposed. In one version, the prototype is itself an exemplar, specifically whichever one is most similar to the other exemplars. In another version, the prototype is a composite of the exemplars; in the third version, a person constructs the prototype by some sort of averaging of the properties of the exemplars. The second and third kinds of prototype would be maximally similar to all the exemplars that were included in the composite or the averaging.

The concept of a prototype as a composite of the exemplars has been challenged. Figure 4 illustrates an objection raised by Wingfield (1979),

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Figure 4

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who argued that a prototype of this sort "would be nothing more or less than a vaguely recognizable blur" (p. 137). Figure 5 shows composites for

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Figure 5

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the two categories of faces in Stephen Reed's study. They are not as blurred as Wingfield's composite dog, and comparing them shows that on average the composite on the left has higher eyes and a lower mouth than the composite on the right. Two points about this comparison are worth noting: First, the "averages" seem to be easy to visualize, perhaps contradicting Wingfield; but second, and in agreement with Wingfield, the composites obscure another difference between the categories--the faces in Category 1, represented by the composite on the right, average a longer nose than the faces in Category 2, as can be seen by comparing the actual exemplars (shown in Figure 3).

Relation to Stimulus Class

Prototype learning is classifiable as a kind of stimulus-class learning. Research participants respond differentially to stimuli from different categories, with reinforcers for correct responses, and eventually respond correctly to new stimuli from these categories without direct reinforcement. Therefore, prototype learning can be studied in animals as well as in humans. However, one feature of prototype-learning studies has not been included in stimulus-class studies with animals: The inclusion of prototypical stimuli in the test items.

The prototype research is also similar to stimulus-generalization research. Stimulus generalization is also classifiable as related to stimulus classes, but with stimuli from natural classes, that is, classes that exist without special training. This research therefore does not provide a good animal analogue to prototype learning in humans. The nearest animal research seems to be the concept learning research by Herrnstein and others with pigeons (e.g., Herrnstein & Loveland, 1964; Herrnstein, Loveland, & Cable, 1976). However, the aim of this research has usually been to establish the fact of concept learning in pigeons, and the aim of the prototype learning research with humans has been to determine how concepts are represented mentally (although Herrnstein et al., 1976, discussed this problem). Looked at another way, the difference is between establishing the existence of a private event and determining the nature of this private event, or investigating the functions of a private event rather than its structure.

Behavior analysts have been concerned with function rather than structure; but when the procedures used in prototype-learning studies are interpreted as procedures for studying stimulus classes, the prototype-learning research clearly deals with stimulus-control functions. Behavior analysts could easily adapt these procedures for animal as well as human research, and could stop at the inductive level of stimulus control rather than proceeding, like the cognitivists, to the level of mental structures.

Schemata

In broad outline, the appropriate schema, or story grammar, for a research report is Abstract, Introduction, Method, etc. Within each of these components, a typical sequence of elements can be identified. For example, the introduction should begin with a statement of the general problem, followed by a review of relevant literature, and end with a statement of the specific problem and perhaps a summary of the method used to attack it. Each of these elements can be subdivided, but such details are tangential to the purpose of the present paper. In one line of research on story grammar, comprehension and recall of texts is found to be easier when their organization corresponds to the appropriate story grammar for texts of that kind (e.g., Mandler & Johnson, 1977). References on story grammars are plentiful. Examples are Hayes and Kelly (1985), Kintsch and van Dijk (1978), Mandler and Johnson (1977), Mistry and Lange (1985), and Thorndyke (1977).

In one line of research on event schemata, or scripts, research participants are asked to describe a routine, stereotyped event, such as Going to a Restaurant, by listing the actions involved. Figure 6 shows

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Figure 6

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data from such a study by Bower, Black, and Turner (1979, Exp. 1). Other relevant references on event schemata, among many, are Abelson (1981) and Mistry and Lange (1985).

The behavioral concepts of autoclitics, setting events, and relational frames seem to be relevant, but explication would require a more detailed examination of schema theories than is appropriate in the present paper.

Superordinate Relations

Superordinate relations of the kind considered here are hypothesized in semantic network theories of meaning (for a sample of relevant references, see Reese, in press). According to semantic network theory, concepts are represented by "nodes," specific-concept nodes are related to superordinate-concept nodes through "links," and features are linked directly to a node at the highest superordinate level at which they distinguish among nodes. For example, as shown in Figure 7, the feature

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Figure 7

"has feathers" is linked directly to "bird," and "eat worms" is linked directly to certain specific birds and not linked to others. Evidence is that the statement "A robin has feathers" is verified as true more slowly than "A robin eats worms." This evidence is hard to interpret behaviorally. However, the corpus of findings as a whole is also hard to interpret cognitively, as I have indicated elsewhere in some detail (Reese, in press).

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Figure Captions

Figure 1. "Prototype A" stimuli used by Nedra Reed. The transformations of Prototype A--and of Prototype B, shown in Figure 2--were developed by Aiken (1970), using a computer program described by Aiken and Brown (1971). In Reed's study, the sizes of the stimuli can be estimated as follows: For Prototype A the longest axis was about 2 1/4 in. (From Reed, 1976, Fig. 1-A, p. 18. Used by permission of the author.)

Figure 2. "Prototype B" stimuli used by Nedra Reed. In Reed's study, the longest axis of Prototype B was about 2 1/2 in. (From Reed, 1976, Fig. 1-B, p. 19. Used by permission of the author.)

Figure 3. Stimuli used by Stephen Reed. The schematic faces differ on four dimensions: Height of the forehead, distance between the eyes, length of the nose, and height of the mouth, each with three possible values. The categories were defined as separated by a linear discriminant function (Reed, 1972, p. 383). Reed did not report the sizes of the figures actually used. (From Reed, 1972, Fig. 2, p. 384. Copyright 1972 by Academic Press, Inc. Used by permission of the publisher and the author.)

Figure 4. A composite dog as Wingfield (1979) suggested it might be conceptualized. (From Wingfield, 1979, Fig. 8.2, p. 198. Used by permission of the author.)

Figure 5. Composites of Stephen Reed's two categories of faces.

Figure 6. Scripts obtained from college students by Bower, Black, and Turner. (From Bower et al., 1979, Table 2, p. 182. Copyright 1979 by Academic Press, Inc. Used by permission of the publisher and the senior author.)

Figure 7. Part of a semantic network representation of animal concepts. (From Anderson, 1980, Fig. 4-13, p. 115. Used by permission of the publisher and the author.)

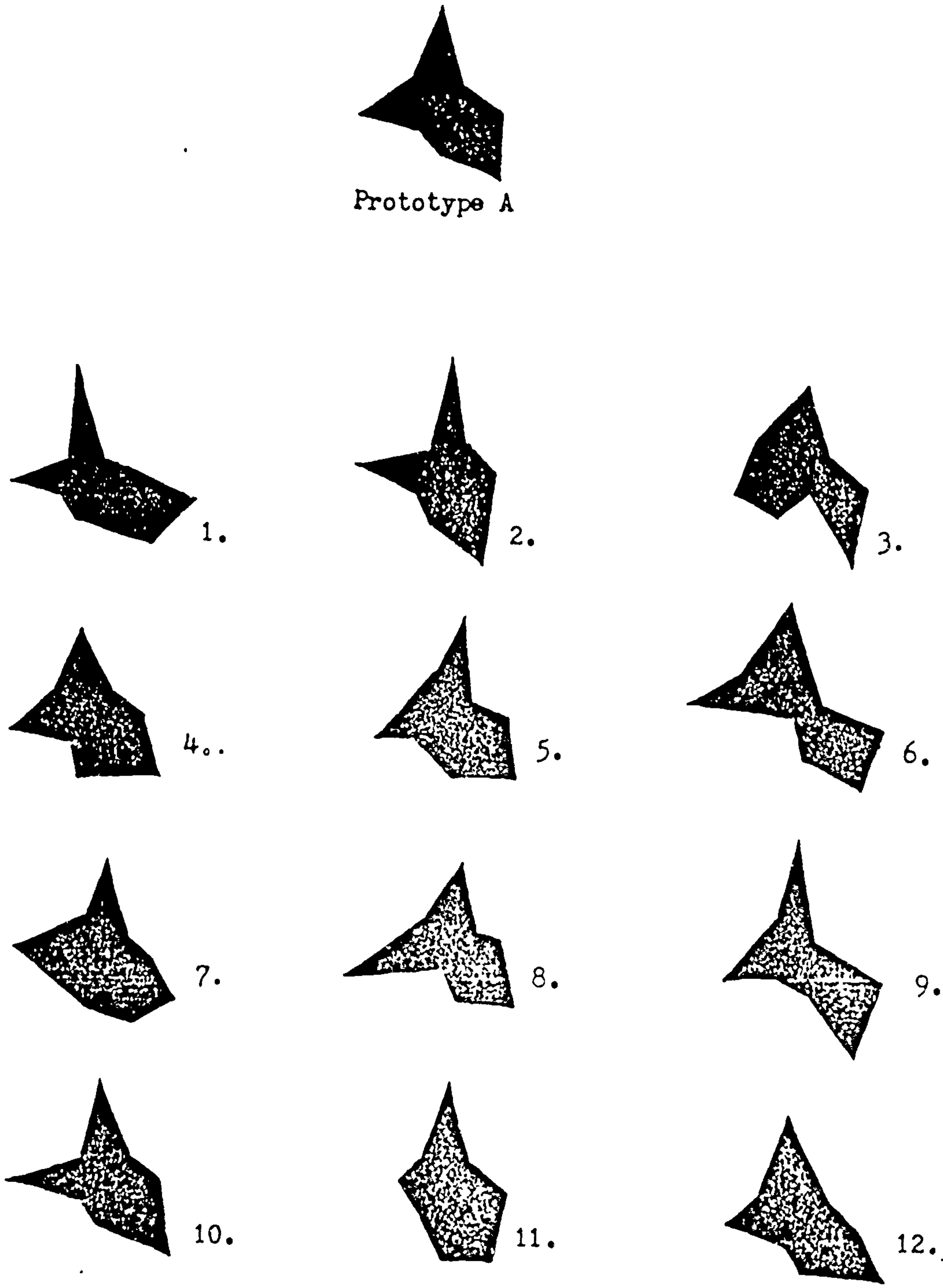


Figure 1

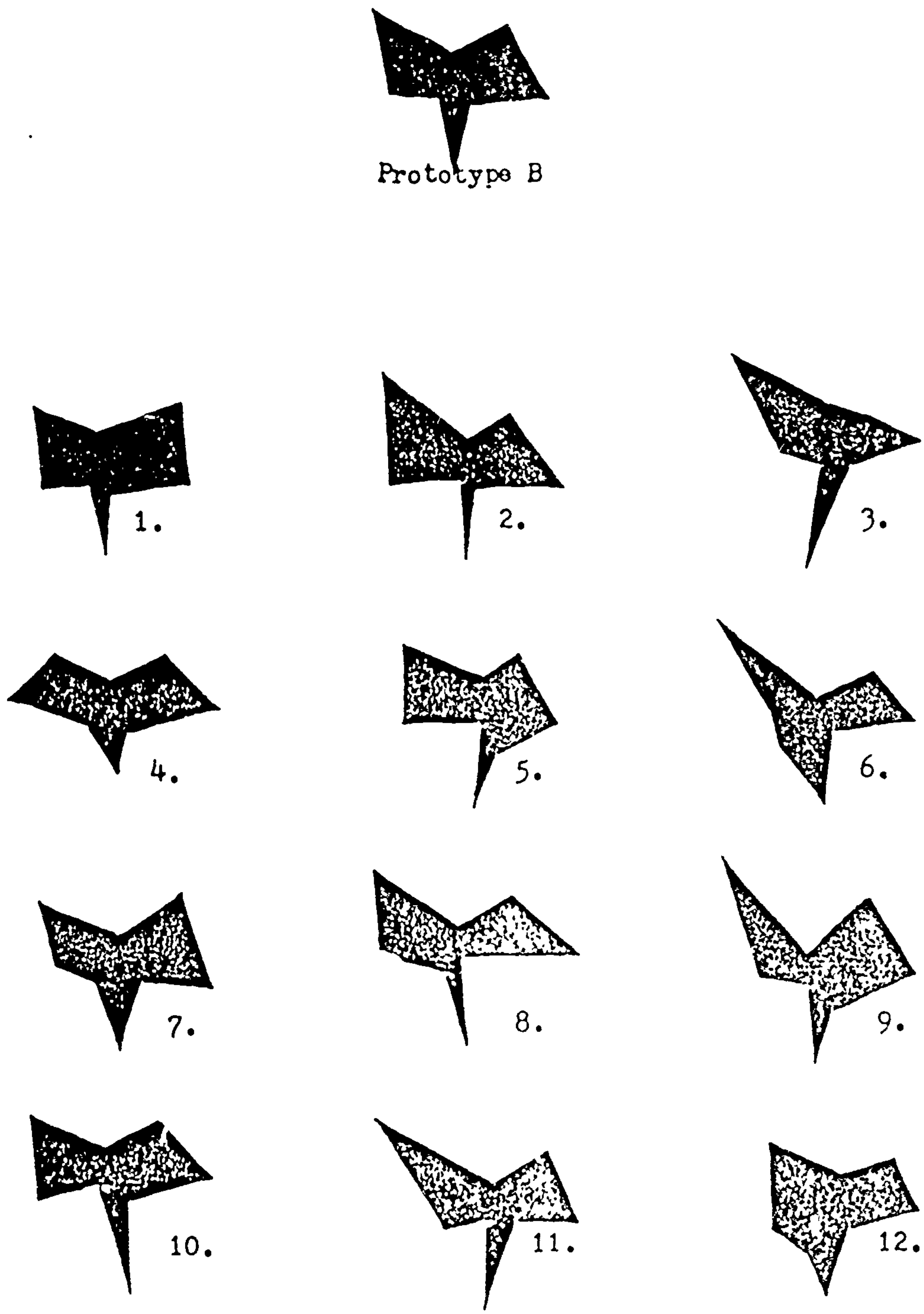


Figure 2

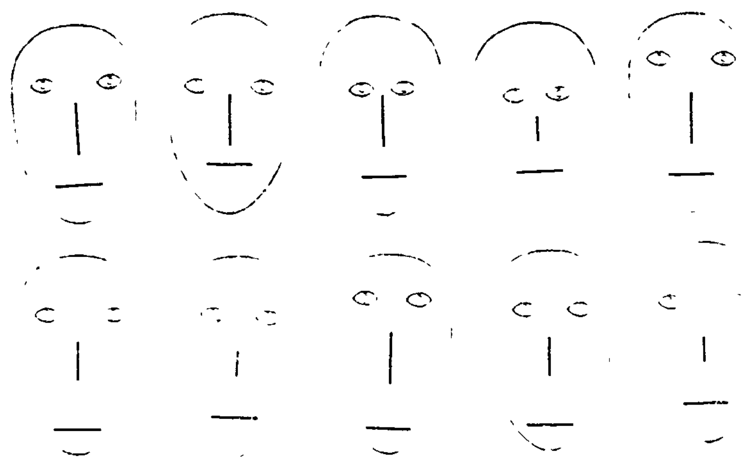


Figure 3

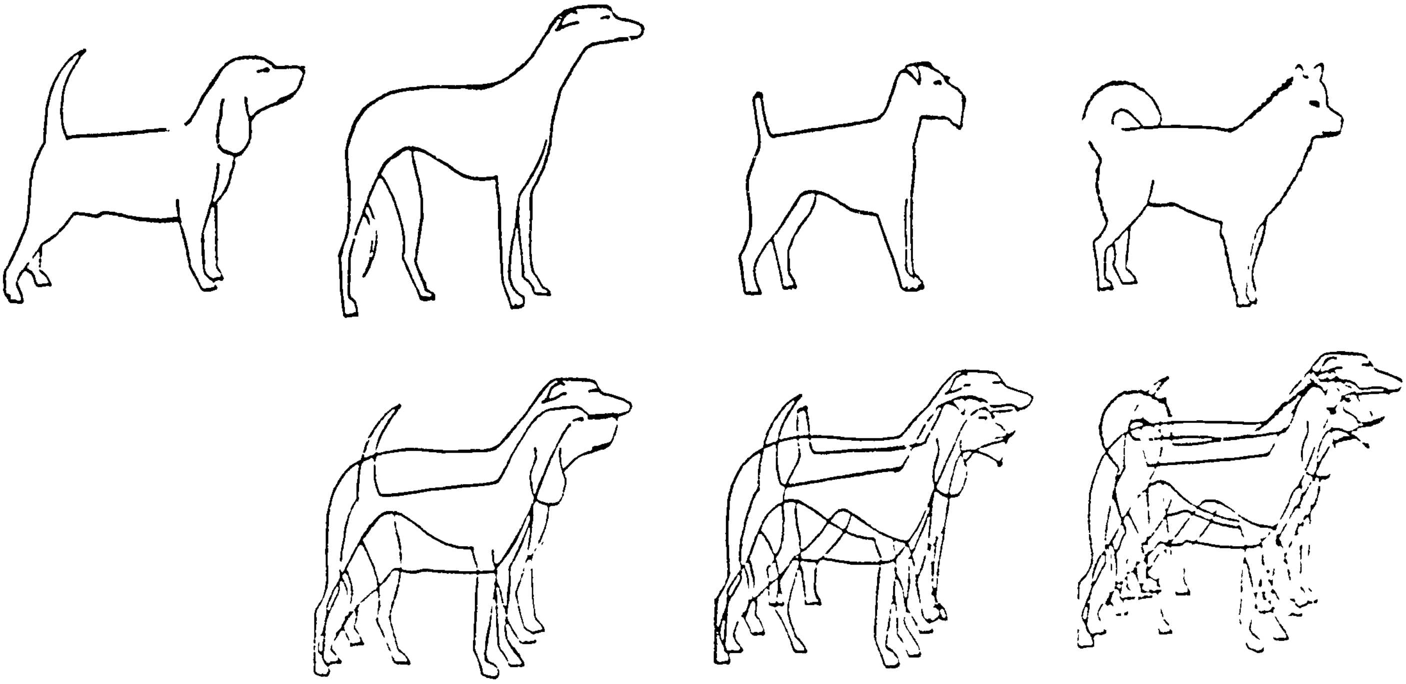


Figure 4

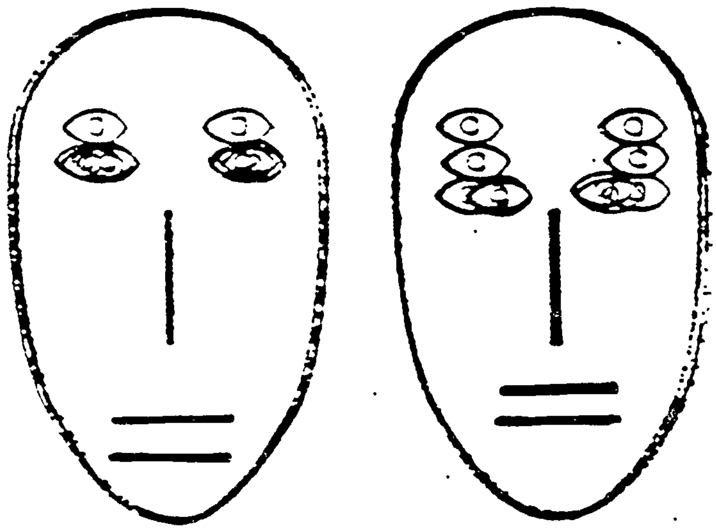


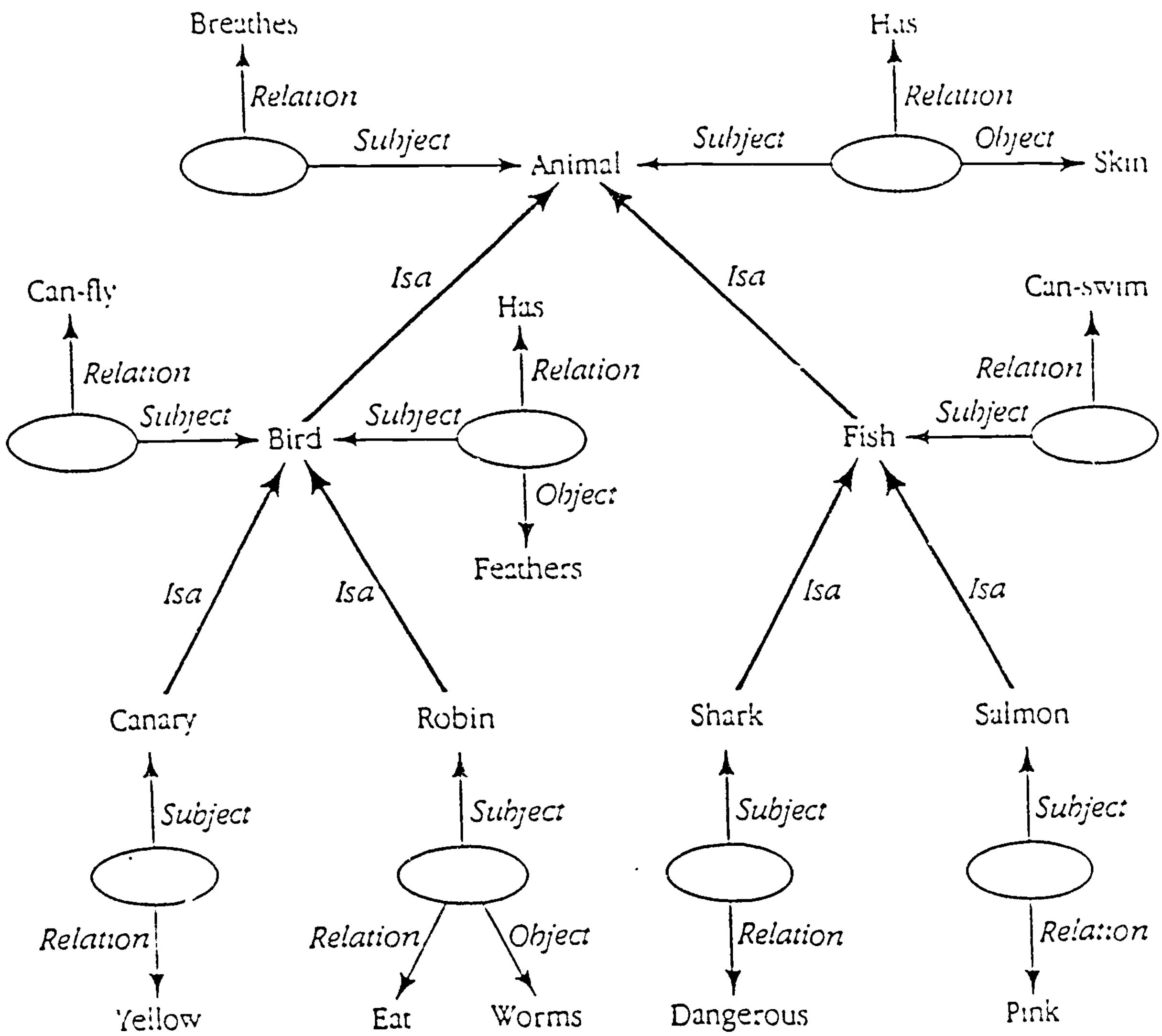
Figure 5

EMPIRICAL SCRIPT NORMS AT THREE AGREEMENT LEVELS

GOING TO A RESTAURANT	ATTENDING A LECTURE	GETTING UP	GROCERY SHOPPING	VISITING A DOCTOR
Open door	ENTER ROOM	*Wake up*	ENTER STORE	*Enter office*
Enter	*Look for friends*	Turn off alarm	GET CART	CHECK IN WITH RECEPTIONIST
Give reservation name	FIND SEAT	Lie in bed	Take out list	SIT DOWN
Wait to be seated	SIT DOWN	Stretch	Look at list	Wait
Go to table	Settle belongings	GET UP	Go to first aisle	Look at other people
BE SEATED	TAKE OUT NOTEBOOK	Make bed	*Go up and down aisles*	READ MAGAZINE
Order Drinks	*Look at other students*	*Go to bathroom*	PICK OUT ITEMS	*Name called*
Put napkins on lap	*Talk*	Use toilet	Compare prices	Follow nurse
LOOK AT MENU	Look at professor	*Take shower*	Put items in cart	*Enter exam room*
Discuss menu	LISTEN TO PROFESSOR	*Wash face*	Get meat	Undress
ORDER MEAL	TAKE NOTES	Shave	Look for items forgotten	*Sit on table*
Talk	CHECK TIME	DRESS	Talk to other shoppers	Talk to nurse
Drink water	Ask questions	Go to kitchen	Go to checkout counters	NURSE TESTS
Eat salad or soup	Change position in seat	Fix breakfast	*Find fastest line*	Wait
Meal arrives	Daydream	EAT BREAKFAST	WAIT IN LINE	Doctor enters
EAT FOOD	Look at other students	BRUSH TEETH	*Put food on belt*	Doctor greets
Finish meal	Take more notes	Read paper	Read magazines	Talk to doctor about problem
Order Desert	*Close notebook*	*Comb hair*	WATCH CASHIER RING UP	Doctor asks questions
Eat Desert	*Gather belongings*	*Get books*	PAY CASHIER	DOCTOR EXAMINES
Ask for bill	Stand up	Look in mirror	*Watch bag boy*	Get dressed
Bill arrives	Talk	Get coat	Cart bags out	Get medicine
PAY BILL	LEAVE	LEAVE HOUSE	Load bags into car	Make another appointment
Leave Tip			LEAVE STORE	LEAVE OFFICE
Get Coats				
LEAVE				

Items in all capital letters were mentioned by the most subjects, items in italics by fewer subjects, and items in small case letters by the fewest subjects

Figure 6



Breathes
Relation
Subject
Animal
Has
Relation
Subject
Object
Skin
Isa
Isa
Can-fly
Relation
Subject
Bird
Has
Relation
Subject
Object
Feathers
Can-swim
Relation
Subject
Fish
Isa
Isa
Isa
Isa
Canary
Robin
Shark
Salmon
Subject
Subject
Subject
Subject
Relation
Yellow
Relation
Object
Eat
Worms
Relation
Dangerous
Relation
Pink

Figure 7