RULES OF RELATION IN SIZE, BRIGHTNESS AND PROXIMITY DISCRIMINATIONS IN THE SQUIRREL MONKEY AND THE RAT.

by

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PREFACE

What it is that is perceived when an organism orients its perceptual system towards an external object or event, is a question of long standing that has proved considerably difficult to answer, since whatever the percept is, is private to the perceiving organism. However, in spite of its inaccessibility, many organized areas of knowledge and investigation have concerned themselves with the question of its nature. Perhaps the most significant of such areas are Philosophy, Physiology and Psychology - each of which has a unique history of development and a unique method of investigation. As a consequence of this differential development, the questions that have been asked of the percept have become modified in each of the different areas concerned.

Contemporary philosophy has modified its questions the least. The problem in perception, qua philosopher, (for example, see Warnock, 1967 and Sibley, 1971) is still seen as that of giving an account of the relationship of sense-experience to the material world. For, it is held, only knowledge of experience is direct and immediate; what we claim to know about the material world is indirect, derivative by inference from what is known directly. The various types of inference from, or ways of interpreting, the sense-data is what erects the percept. The identification of this sense-data and the processes whereby the percept is, thus, erected, is one of the concerns of contemporary philosophy.

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Some investigators employing the 'scientific method' have rejected this introspective method, thus described, as a process for the production of raw data from which theorizing can begin. Scientists subscribe to the view that the raw data must be collected in an objective and publicly observable/verifiable way and related to equally objective measures of the material world. The style of this raw data largely determines in which of the developed areas of knowledge each investigation is described. Physiologists have as their raw data measures of electrical and chemical activity of body tissue, detected, measured and recorded with the aid of modern technology. In asking questions of the percept, physiologists present features of the material world to organisms and relate them to the resulting electro-chemical changes associated with (more often than not) the organism's nervous system. The modified question that the physiologist has come to ask is not what <u>is</u> the percept or the experience, but what responses in the body tissues represent particular features or feature-changes in the material world (for example, see Horridge, 1968 and more specifically Hubel and Wiesel, 1968). The physiologist impinges easily identifiable and quantifiable features of the material world (usually presented in isolation - for example, light bars in a totally dark field) upon the <u>passive</u> perceptual system of a restrained, and often comatose, organism; and it is a relatively uncomplicated task (although technically intricate) for the experimenter to identify the feature-to-be-perceived, quantify it, measure the body tissue response with appropriate gadgetry, and relate response and feature.

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The situation is not nearly no simple for the experimental psychologist. Like the physiologist, the experimental psychologist had adopted the 'scientific method' as the method of inquiry, with all the related objectivity. The gross behaviour of the organism (the external manifestation of its 'mental life') is used as raw data, and is analogous to that of the physiologist but on a molar scale. However, since the behaviour of the whole organism is not spontaneously under the same degree of control by the features of the material world as is the micro-behaviour of the physiologists' investigations, the questions that the physiologists ask of the percept would not be appropriate to psychological investigations. However, whilst the whole organism may not respond in a spontaneous and reliable way to particular, presented features of the material world, it can be made to do so providing it is appropriately motivated. It is this that forms the basis of a large number of experimental procedures that psychologists have designed to ask questions of the percept - particularly (but not exclusively) when non-verbal subjects are used. The procedures or paradigms that have been developed involve training the organism to respond differentially to objects of the material world (each one, a collection of features, themselves). That differential responding can be taught (or cannot be) can indicate whether or not the organism can perceive at least one of the differences existing between the presented objects and respond accordingly. Subsequent variations of this procedure serve to identify with more precision the feature or features used in the control of the trained behaviour.

Thus, for the experimental psychologist, the question of what is the nature/

nature of the percept becomes modified to one of what does the organism use (of what may, perhaps, be perceived) in learning to differentially respond to those objects which are presented-to-be-perceived. For the psychologist using these Discrimination Learning Paradigms (which is what these procedures have come to be called), the questions of perception have become inexorably associated with questions of learning, since it is through learning procedures that the psychologist's operational version of the percept can be interrogated.

C O N T E N T S

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B. T. Jones. October, 1974.

S U M M A R Y

Using size, brightness and pattern stimuli, in discrimination learning experiments, it is concluded that in the squirrel monkey (and probably in the rat) the perception of relations is a necessary condition for stimulus analysis.

Monkeys readily exploit perceived relations between size stimuli when required to select the larger/largest stimulus from a set. However, when required to select one particular size, monkeys base their successful choice on some (exocentric) relation amongst alternate stimuli and on some (exocentric) relation between the particular stimulus and the context in which that stimulus appears - for the introduction of novel size stimuli and/or the removal or manipulation of the visual context disrupts the performance of the latter subjects (i.e. the 'specific' stimulus condition), but not the former (i.e. the 'largest' stimulus condition). In the case of specific stimulus learning in the absence of the visual context, rules of relation (egocentric) between the stimulus and the perceiver appear to operate.

Where comparison is possible, comparable results were obtained with stimuli that differed in brightness.

In the case of stimulus patterns which differ in terms of spatial organization, the relation between the pair of stimuli comprising the discriminanda is seen to be crucial in constraining the possible organizations/

organizations that can be imposed upon a single stimulus. The single stimulus, thus, becomes a function of the set in which it is embedded. The significance of this is discussed in respect of 'physiological' explanations of pattern recognition.

The suggestion is put, that a study of the co-ordination of the different types of relation in the different species may prove a sound basis for the development of a comparative psychology of learning and perception.

Finally, the questions, herein, arose from a dissatisfaction with the conventional approach to discrimination learning as seen (in various guises) in terms of the so-called Absolute/Relational controversy. The logical point was made that it is impossible to conceive of an 'absolute' stimulus and that a specific stimulus value can only have identity in terms of some referent. The majority of experiments reported in this thesis spring from an attempt to recognise such referencing systems.

Figure and Tables are located in the text on the page following that on which they are first quoted. Each figure-number, table-number and experiment-number is followed by the appropriate chapter-number. For example, the fifth experiment in the second chapter (Experiment 5-2) refers to two tables which are the fifteenth and sixteenth in that chapter (Table 15-2 and Table 16-2).

C H A P T E R 1

THE LOGICAL NECESSITY OF RULES OF RELATION IN DISCRIMINATION LEARNING.

In an organism's commerce with its environment, different objects need to be responded to in different ways. The process by which this is brought about is called discrimination learning.

The proposition that animals discriminate by perceiving relationships between stimuli is a fundamental assumption of Gestalt psychology, which subscribes to the view that the perception of inter-stimulus relations is primitive. Köhler (1929) writes:

". . . the individual (elements) appearing in a pair (of stimuli) attain an inner union. Their role in this union . . . depends not upon their absolute qualities, but upon their place in the system they compose."

Spence (1937), on the other hand, specifically denies the proposition and maintains that it is not until the advent of language (which he conceives as an important mediator in discrimination tasks) that it becomes necessary to account for discrimination learning in terms other than those involving simple attachments of responses to absolute stimulus values - using concepts derived from Pavlovian psychology and adapted for instrumental learning.

A vast literature exists which has attempted to resolve the question of so-called relational or absolute learning. However, an exhaustive review of this work (Reese, 1968) reveals much that is contradictory and even in such an extensive undertaking, supports little or no secure generalizations with respect to what is learned when animals learn to discriminate. The experimental work reviewed appears to have been addressed to inappropriate questions based on a series of conceptual confusions/

confusions which centre around the following problems:

1. The status of the concept of the 'absolute' stimulus.
2. The polymorphous nature of the term 'relation' in relational learning.

1. <u>The status of an 'absolute' stimulus</u>.

It is a purely logical point that there can be no such thing as an 'absolute' stimulus - a specific stimulus value must be identified in relation to some referent or other. It is impossible to imagine how any specific stimulus value can be detailed in terms of <u>only</u> that stimulus. Boring writes of this (Boring 1933, page 95):

". . . the perception of size consists of the discrimination of relative sizes."

and

". . . the instance of the perception of an 'absolute size' throws more light on the matter. In strict logic size has meaning only relativistically."

If a specific size, for example, is to be identified in a typical discrimination learning situation, then if it is not evaluated by comparison with other presented stimuli then it must, at least, be evaluated by comparison with other environmental invariants (for example, the different structures/

structures in the testing apparatus) or, indeed, by comparison with the perceiver, himself - either 'as big as my visible hand', 'as high as my visible shoulder' or 'big enough to hide behind', 'small enough to pull towards me', etc. The set of relations involved in perceptions such as these is certainly not simple - for example, Brunswick 1956 refers to some of them as ratio-morphic or reasonlike processes - and their complexity and great diversity is, in no sense, contained by the 'absolute' stimulus models of Spence and the Behaviourists.

2. The polymorphous nature of the term 'relation' in relational Learning.

Apart from the fact that egocentric judgements about stimuli without reference to other stimuli of the same class or other classes is clearly a relational judgement, what of the relationships between discriminada? Are different types of relationships recognized by investigators seeking to establish (and disprove) 'relational' theories of discrimination learning? Gestalt theorists, themselves, have not always recognized such distinctions - for example, between stimulus relations which are no more than perception of ratios of excitation (Lashley 1938) and higher order relationships such as the 'higher order equivalence' referred to by Miller and Chomsky (as cited in Kolers and Eden, 1968). At least the evidence for one type of relation (ratios of excitation) has been/

been used to encourage support for others (see Lashley 1938). As a consequence, 'critical' tests of so-called relational learning have often been made under conditions which are hardly appropriate.

Perceptual rules, for example, may well emerge following comparison of only two relevant stimuli as in the celebrated experiments of Krechevsky (1938b) where only rats trained with stimuli "which force the appropriate organization" organized dot-matrices according to the Principle of Proximity (and discussed, fully, in Chapter 4). Cognitive rules of relation, on the other hand, would require the exposure of the subject to at least a few parental instances (in practice, many such instances) of a class before an appropriate rule of relation could be generated. In the former case, the <u>choice</u> of stimuli but not necessarily their number ought to be crucial in determining the type of perceptual organization which will emerge; in the latter case, the attributes of the stimuli employed are clearly important, but the <u>number</u> of exemplars presented is equally important. In the vast majority of 'transposition' studies, however, designed to investigate stimulus relations which are rarely ever specified, the usual number of stimuli involved in the training set is two!

The experiments reported in the following chapters spring from an attempt/

attempt to determine some of the rules of relation which must be involved in discriminations between (i) objects of differing size (Chapter 2), (ii) stimuli which differ in the attribute of brightness (Chapter 3) and (iii) patterns which differ in their spatial organization (Chapter 4). In (i) and (ii), both so-called absolute and relational learning is encouraged, and the (necessary) relationships involved in both types of learning (should both types be present) are sought.

C H A P T E R 2

RULES OF RELATION INVOLVED IN

DISCRIMINATING BETWEEN OBJECTS

THAT DIFFER IN SIZE.

The suggestion was advanced in the previous chapter that it should prove instructive to attempt to answer the general question of what is learned (about) during discrimination learning, in ways not necessarily following those that have been the convention. In the majority of studies, the convention has involved training the subjects to discriminate between a number of stimuli and, subsequently, introducing these subjects to novel situations, giving them the opportunity to transfer whatever they have learned about the original (training) situation to the new situation - with the reasonable expectation that the performance in the new situation should give some indication as to the nature of the basis of the original discrimination. In principle, the practice of seeking equivalence, in terms of the discriminanda, between the original problem and the subsequent test problem is sound, since in the test problem the stimuli can be highly constrained to allow specific properties of the original discriminanda to be examined and their respective contribution to the discrimination assessed (see, for example, the methods advocated by Klüver 1933 and Sutherland 1962).

However, in practice, the range of 'new situations' that have been employed following discrimination training has not been large and has been little serious test of the various theories of discrimination learning that have arisen. This appears to be especially true of those theories which have arisen in and around the so-called Absolute-Relational controversy with respect to explanations of discrimination learning in non-verbal animals, and with which this thesis is concerned. With relatively limited information derived from only a small/

small range of types of post-discrimination learning tests, only a little ingenuity has been required to make a number of widely disparate theories accommodate a large proportion of this data. This suggests that either the testing procedures employed are inappropriate with respect to the questions asked of discrimination learning or the questions, themselves, are misplaced. It is the current contention that the latter is the more likely explanation, for reasons that have been detailed in the previous chapter.

If it is, indeed, the case that in discrimination learning situations both so-called absolute and relational qualities of the discrimination can become patent cues in the production and maintenance of discrimination behaviour (as the review referred to in the previous chapter suggests), then the interesting question arises as to the conditions which favour one set of attributes rather than the other. This question has not gone unrecognized (for example, see Gonzales, Gentry and Bitterman 1954), but little planned work has been carried out to allow such conditions to be identified. Further, in view of the conceptual confusions surrounding the term 'absolute' stimulus (i.e. the logical absurdity of the concept) and the term 'relation' (i.e. the polymorphous nature of the concept) which have previously been detailed, it would, indeed be surprising if any such work would/could permit of clear interpretation. However, if the conceptual scheme is adopted in which <u>every</u> stimulus attribute has its identity in some referent or other (as discussed in Chapter 1), then the problem becomes not one of identifying the dichotomous conditions under which either absolute or relational learning might occur but, in the first instance, one of identifying/

identifying the variety of referents that can be used. Such a quest, if successful, would be likely to uncover, itself, the conditions under which some referents are favoured over others. This approach is seen as even more reasonable when it is remembered that there is little that ought to be inviolable with respect to the classical dichotomy - which was born of historical considerations, rather than theoretical or empirical.

Chapter 2 reports a series of experiments which are designed in an attempt to recognize the different types of referents that one species of non-human primate might employ in learning to discriminate between stimuli that differ along the dimension of 'size'. The general method of investigation differs in important ways from those that have been previously used:

In the initial phase of the series of experiments, a paradigm is used that will encourage (but not necessarily guarantee) some subjects to learn the discrimination in what has been classically called the 'absolute' manner, whilst others will be encouraged to learn the discrimination in the 'relational' manner. In more specific terms, the paradigm will require one group of subjects to be trained to conserve a relationship between stimuli of variable proportions, whilst the other group will be trained to conserve the choice of a single stimulus of invariant proportions. It is by no means inconsistent to adopt the already much criticised classical dichotomy as the starting point for the series of experiments, since it is within this dichotomy that the variety of potential relationships, that have been discussed in Chapter

1/

1, must exist. Whilst experiments in which the performance of such different groups has been compared are not new (for example, Wolfle 1937 and Meyer 1964, both using rats), little, if any, subsequent investigation of the possible (different) bases for whatever rules of responding had developed has been carried out. One criticism that the current author has already made is that the testing procedures following discrimination training have been much limited in their scope - most probably the result of asking inappropriate questions of the discrimination learning, and already discussed in Chapter 1. The experiments reported in the current chapter represent a much more extensive post-discrimination training investigation - derived from the novel conceptual standpoint outlined in Chapter 1.

E X P E R I M E N T 1 (2)

INTRODUCTION

The purpose of the current experiment is to compare the acquisition behaviour of two groups of primates treated identically in every respect, save their reward contingencies. One group is trained to conserve a relationship between stimuli of varying proportions (varying from trial to trial) and the other group is trained to conserve the identity of a stimulus of invariant proportions from this very same stimulus set (varying from trial to trial in a manner identical to that of the former group). Effectively, Experiment 1 (2) compares the acquisition performance of primates encouraged to learn in an 'absolute' manner with those encouraged to learn in a 'relational' manner. The further purpose was to produce two different kinds of learning (at least, that were different in their aetiology) which could, subsequently, be examined in considerable detail.

METHOD

Subjects

Eleven male common squirrel monkeys (*Saimiri sciureus*) which are New World monkeys (*Ceboidea*) served as subjects. They were imported by, and bought from, Shamrock Farms Ltd., Brighton, England. They comprised three adults and eight juveniles which were approximately three years old and ten months old, respectively, at the onset of pretraining. All subjects were experimentally-naive at the onset of pretraining/

pretraining, also.

Subjects were housed in two adjacent colony rooms maintained in accordance with Home Office (Cruelty to Animals Act, 1876) and Ministry of Agriculture and Fisheries (Quarantine) regulations. They were caged in groups of two or three monkeys, and different cage-groups within each colony room were in visual and acoustical contact with one another. The cages were constructed of galvanised metal with solid back and sides and wire-mesh front and top. The dimensions were approximately 3' x 3' x 3', permitting relatively unrestricted movement. Each cage was provided with perches and swings, and had a twenty-four hour supply of water available. Subjects were fed M.R.C. Diet 2 (vitamin C enriched) pellets, daily, for approximately eight to ten hours following experimental sessions (or at the appropriate time of day in the absence of such sessions). At weekend, carrots and a variety of fruits were made available and occasionally further vitamin supplements (as directed by the vetinary service). Their only other source of food was by reward obtainable during training and testing sessions, usually consisting of one shelled half-peanut (occasionally, diced carrot or apple of an equivalent size was used as reward).

Apparatus

All monkeys were trained and tested in a Wisconsin General Testing Apparatus (W.G.T.A.) first described by Harlow and Bromer (1938). The reduced-size version used in the experiments reported here (to better suit the diminutive squirrel monkey) was constructed of ½" chipboard and covered with several coats of matt mid-grey, waterproof paint. The stimulus tray was 11" wide and 6" deep and mounted on rails to facilitate/

facilitate easy to-and-fro movement. The colour of the stimulus tray and the number and position of the foodwells was varied according to the needs of the respective experimental session. (these details will be reported at the appropriate parts of the report). The foodwells, however, were sufficiently deep to allow the reward to be contained without protruding above the surface of the stimulus tray.

Subjects were carried to, and placed in, the W.G.T.A. contained in aluminium testing cages (supplied by Forth-Tech Services Ltd., Dalkeith, Scotland) which were 24" long, 24" high and 12" wide with vertical frontal bars 1½" apart. The W.G.T.A. was designed and built around the dimensions of the restraining cages. Subjects viewed the stimulus tray through the frontal part of the cage and through a rectangular aperture 12" high and 11" wide in the W.G.T.A. This aperture was controlled by a vertical sliding opaque screen connected to the experimenter by a cord and pulley system. The arena containing the stimulus tray measured 11" wide and had side walls 24" high, and allowed forward-and-backward travel of the stimulus tray of 12". The arena was separated from the experimenter by a limited-vision screen, also controlled by a cord and pulley system. With the stimulus tray at the front of its travel (i.e. at the subject-end of the rails in the arena) the foodwells were 2½" from the bars of the restraining/testing cage, and the surface of the tray was 1¾" above the level of its floor. The reach of the subjects into the arena from the cage was approximately 6", and when the tray was at the back of its travel (i.e. at the experimenter-end of the rails in the arena) it was well outwith the reach of the subjects.

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The arena was lit by a 150 watt bulb situated approximately 2' x 6" above the side walls and centered on the arena, (except in some experimental sessions where alternative lighting conditions were essential - this will be detailed at the appropriate part of the report).

Stimuli

Stimuli were cut from commercial, white polystyrene, coated with a layer of alabaster and sanded very smooth. Less durable polystyrene was chosen in place of (for example) wood as the stimulus material, since the weight-differential between stimuli of different sizes would be much reduced. This was regarded as important, since subjects were to be asked to make size judgements using visual information.

Durability of the polystyrene stimuli was increased by using a protective coating of alabaster; this also had the effect reducing and standardizing the surface texture of the different stimuli. A coating of washable matt white paint served to reduce the surface texture, further, and to standardize the stimulus colouring. Some experimental sessions required the stimuli to be prepared in a different way - the details of these stimuli will be reported in the appropriate part of the report.

The normal stimuli were cuboid in shape and the stimulus pool made up of nine different sizes: ranging from $2\frac{1}{2}$" cube down to a $\frac{1}{2}$" cube in intervals of $\frac{1}{4}$" (see figure 1-2), producing a linear progression in terms of length of side of cube. Linear progressions could have been produced in terms of area of face or volume of cube, for example, but there/

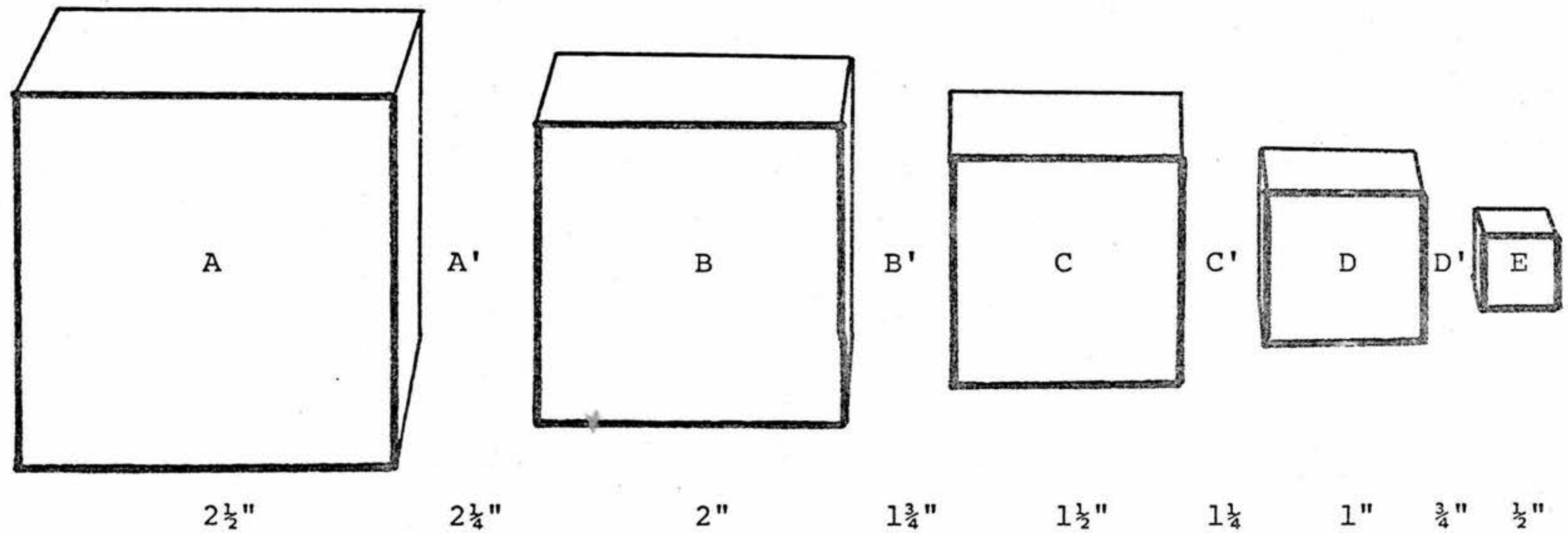


Figure 1 (2). The normal pool of size stimuli used in the series of experiemtns reported in Chapter 2.

Note: Only 5 of the pool of 9 stimuli are actually drawn.

there is no *a priori* reason for supposing that one would have been more appropriate than the other. Many exemplars of each stimulus size made up the stimulus pool which was frequently washed during single experimental sessions and repainted between experimental sessions. For Experiment 1 (2), Stimulus B, C and D were used, painted in the normal matt white.

Shaping and Pretraining

Shaping and pretraining was said to be complete when the subject could be seen to orient towards, approach and displace one of a pair of identical pretraining stimuli when presented on the stimulus tray, made accessible to the subject by the vertical sliding of the opaque screen, and the retrieval of a reward from beneath the displaced stimulus - the upward sliding of the opaque screen becoming the 'cue' for the availability of food (reward). Pretraining was continued until the latency of response was usually not greater than five seconds; then, discrimination training of Experiment 1 (2) was begun. The process by which this was achieved was as follows:

All the subjects were allowed to become familiar with the colony room, their cages and the routine of the laboratory for a period of several weeks to several months before shaping and pretraining was begun, and before they were introduced to the W.G.T.A. During this period, much hand-feeding by the experimenters went on and the subjects were generally 'tamed'. Also during this period, they were made familiar with the restraining cages which were used as holding cages during routine cleaning and animal inspection duties.

The stimulus tray used in pretraining was painted matt red and contained/

contained two foodwells situated 6" apart and $1\frac{1}{2}$" from the subject-edge of the tray. This tray was used in Experiment 1 (2). The stimuli used in the shaping and pretraining session differed from those of the stimulus pool previously described. Whilst they were made of white polystyrene, they were rough-textured, very irregularly shaped, not covered with alabaster and unpainted. As far as was possible, the stimuli of the pretraining pool were identical. Formal shaping and pretraining took approximately five days.

Day one and two. Subjects were hand-fed in the W.G.T.A. and adapted to the moving parts of the apparatus. Then, with the two-stimulus tray at the back of its travel, the limited-vision screen raised and the opaque screen raised, both foodwells were baited with shelled half-peanuts in full view of the subject. The tray was moved to the front of its travel and the subject permitted to retrieve the contents of one foodwell, at which point the tray was withdrawn to the back of its travel. After fifteen seconds both the foodwells were baited again and the procedure repeated for ten to fifteen trials. If a subject made three consecutive responses to one foodwell, the reward was removed from that well for the following two trials, in an attempt to equate the subject's responses to each side.

Day three. A series of similar trials were administered on Day Three, but after the first two trials a pair of identical pretraining stimuli were introduced behind, but not covering, the foodwells. Gradually, throughout these trials, the stimuli were moved progressively closer to the foodwells, half-covering them, and finally completely covering them such that in order to retrieve the contents of a foodwell, the subject/

subject had to displace one of the stimuli. Ten such trials (i.e. with totally covered foodwells) completed the day's testing.

Day four and five. During the final stage of pretraining, both the opaque screen and the limited-vision screen were brought into use. With the opaque screen lowered (thus, preventing the subject from viewing the stimuli arena) both foodwells were baited and covered with the pretraining stimuli. With the limited-vision screen lowered and the stimulus tray at the back of its travel, the opaque screen was raised and the subject allowed to view the contents of the stimulus tray for a five second period. The tray was then moved to the front of its travel and the subject allowed to respond as before. Immediately following the removal of the contents of one foodwell by the subject, the trial was terminated by the withdrawal of the tray to the back of its travel, out of the subject's reach, whilst the opaque screen was lowered. During the period from the raising of the opaque screen to the arrival of the tray at the front of its travel, the experimenter's eyes were averted to prevent unintentional shaping of the subject's behaviour (especially important in later stages of the experiments). The inter-trial interval was approximately fifteen seconds, and fifty trials were given over Day four and five. During these trials the subjects' responses to either side were balanced over blocks of ten trials (as before), in order to prevent the development of spatial preferences which could interfere with subsequent experimentation.

Throughout this pretraining period, white noise (up to approximately sixty decibels) was gradually introduced into the test room through a

7"/

7" loudspeaker mounted above the W.G.T.A. Within the confines of the test room (which was approximately 5' wide x 8' high x 8' long) this was well sufficient to suppress sounds from adjacent activity. This level of white noise was maintained in all subsequent experiments.

Procedure

Each subject was tested, daily, for thirty trials. Stimulus pairs B v C and C v D were presented in a predetermined, 'randomly-alternating' series, balanced over blocks of twelve trials (Fellows, 1967). The laterality of the stimulus pair that was presented was determined by specifying, on each trial, the location of the rewarded stimulus of that pair, using a further predetermined sequence (Fellows). Gellerman series (Gellerman, 1933), were not used following criticism by Fellows that by adopting certain feasible hypotheses independent of the discriminanda, subjects could still come to deviated significantly from chance responding - and, clearly, this could interfere with both discrimination training and (more importantly) subsequent equivalence or transfer testing.

Subjects were in the W.G.T.A. in their testing cage, and allowed a five to ten minute 'settling down' period. With the opaque screen down, the limited-vision screen up, and the stimulus tray at the back of its travel, the appropriate foodwell was baited (Fellows series 1), and the appropriate stimulus pair (i.e. B v C or C v D) was selected (Fellows series 2) and oriented according to whichever was the positive stimulus. The limited-vision screen was lowered and the opaque screen raised. The subject was allowed to view the out-of-reach stimulus tray for five seconds. It was then pushed to the front of/

of its travel (with the experimenter's eyes averted) to allow the subject to respond. The subject was said to have responded when he <u>moved</u> a stimulus with his hand. If no response had been forthcoming within fifteen seconds, the opaque screen was lowered, the tray removed to the back of its travel and the trial terminated. After an inter-trial interval of fifteen seconds the same trial was re-run.

If the subject made a correct response, he was allowed to retrieve the reward, and the opaque screen was lowered while the tray was moved to the back of its travel. The correct response was then recorded. If the subject made an incorrect response (i.e. he moved the negative stimulus), the stimulus tray was moved to a position just-out-of-reach before he had the chance to respond to the other (correct) stimulus. The subject was then allowed to view the disturbed stimulus configuration on the tray for five seconds and then the opaque screen was lowered to terminate the trial. A correction procedure was adopted, in this event, (an experimenter-correction procedure rather than a subject- or self-correction procedure) which meant that the trial with the <u>same</u> stimulus configuration was re-run after the inter-trial interval of fifteen seconds. This procedure was continued until a correct response occurred. Care was taken during the changing of the stimuli (if such change were needed) and the baiting of the appropriate foodwell, to ensure that the noises thus produced could not help the subject in the forthcoming trial. For example, if the stimulus configuration needed to be presented unchanged, the stimuli were lifted off the tray and replaced in the same way as if a stimulus change was actually being made; further, the tendency to take a stimulus and/

and cover the foodwell that had just been baited was resisted, and a random pattern adopted. The stimulus arena and the stimulus tray were brushed clean of debris during the inter-trial interval, and new stimuli were regularly drawn from the large stimulus pool.

Discrimination training was carried out up to a criterion of acquisition of eighteen correct responses out of twenty consecutive trials - Criterion 1 - and correcting trials were ignored in the computation. If at the end of the day's thirty trials, a subject could reach criterion in a further two trials, then these two trials were run. Following reaching the 18/20 criterion (the conventional benchmark) training was continued until a more severe criterion of not more than one error per day for three consecutive days was reached - Criterion 2. This is more strict a criterion than eighty seven correct responses out of ninety consecutive trials.

Design

Each of the eleven subjects was assigned to one of two experimental groups, for Experiment 1 (2): the Specific-Stimulus Training Group (Group SS, comprising six subjects) and the so-called Relational Training Group (Group R, comprising five subjects). Both groups received two-stimulus presentation discrimination training with stimulus pairs B v C and C v D, presented on 'randomly-alternating' trials. Group SS had responses to Stimulus C rewarded when either stimulus pair B v C or C v D was presented. Group R had responses to Stimulus B rewarded when stimulus pair B v C was presented, and to C when C v D was presented. Each group was treated identically with the exception of the reward contingencies. Figure 2 (2) illustrates the design/

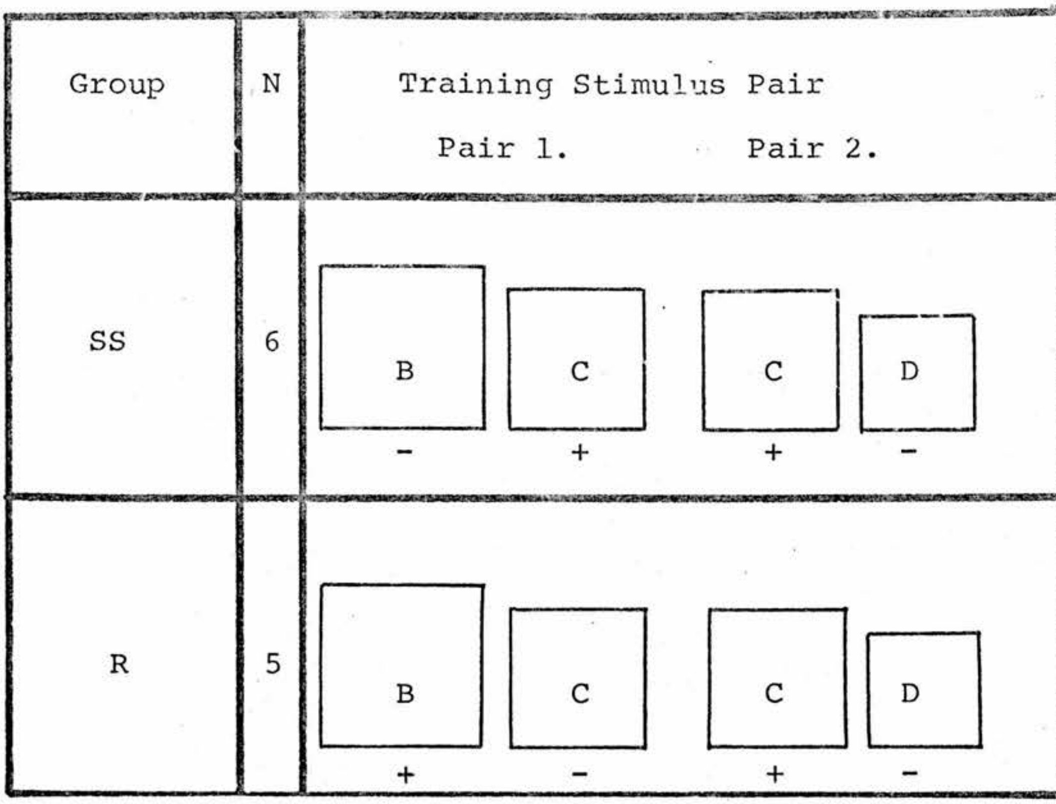


Figure 2 (2). The response contingencies and the stimulus-pairs used in Experiment 1 (2).

Note: Pair 1 and pair 2 were presented in randomly alternating manner.

design of Experiment 1 (2).

RESULTS

Following pretraining, no subject had a response latency greater than three or four seconds. Most were of the order of two seconds.

Performance up to Criterion 1

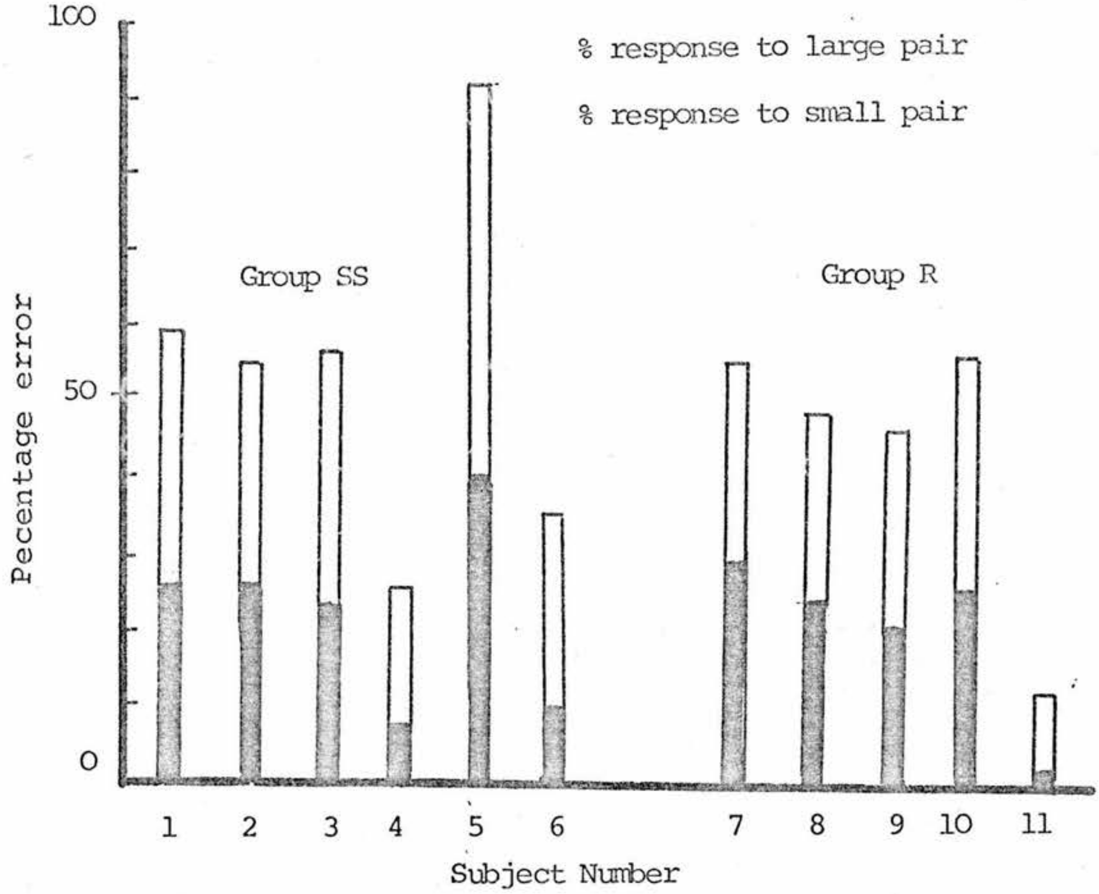
Table 1 (2) displays the performance of the two groups in terms of both trials and errors to criterion. Further, the number of errors to the smaller and larger stimulus pair are recorded for each subject (i.e. pair C v D and B v C, respectively) - the smaller and larger stimulus pairs were presented an equal number of times for each subject. Although the mean number of errors to criterion for Group SS is greater than for Group R, this difference is not significant (t-test for independent measures - $t = 0.6$; $df = 9$; $p > 0.5$ for a two-tail test). Similarly, the mean number of trials to criterion is greater for Group SS than for Group R, but does not reach significance (t-test for independent measures - $t = 7$; $df = 9$; $p > 0.5$ for a two-tail test). Neither Group SS nor Group R made significantly more errors to one or other of the stimulus pairs (t-test for related measures - Group SS: $t = 2.35$; $df = 5$; $p > 0.05$ for a two-tail test. Group R: $t = 1.10$; $df = 4$; $p > 0.10$ for a two-tail test). The appropriate histogram of Figure 3 (1) displays the performance of the two groups, graphically, up to Criterion 1.

Performance up to Criterion 2

Rather/

Group	Sub.	Trials	Errors		
			Total	Smaller pair-CD.	Larger pair-BC.
SS	1	138	58	28	30
	2	110	53	28	25
	3	133	54	23	31
	4	86	25	11	14
	5	221	92	41	51
	6	105	35	13	22
	Mean	132	53	24	29
R	7	126	55	29	26
	8	132	48	24	24
	9	127	46	22	24
	10	141	56	26	30
	11	54	13	1	12
	Mean	116	44	20	24

Table 1 (2). The performance of the 2 groups upto Criterion 1 (i.e. 18/20), of Experiment 1 (2).



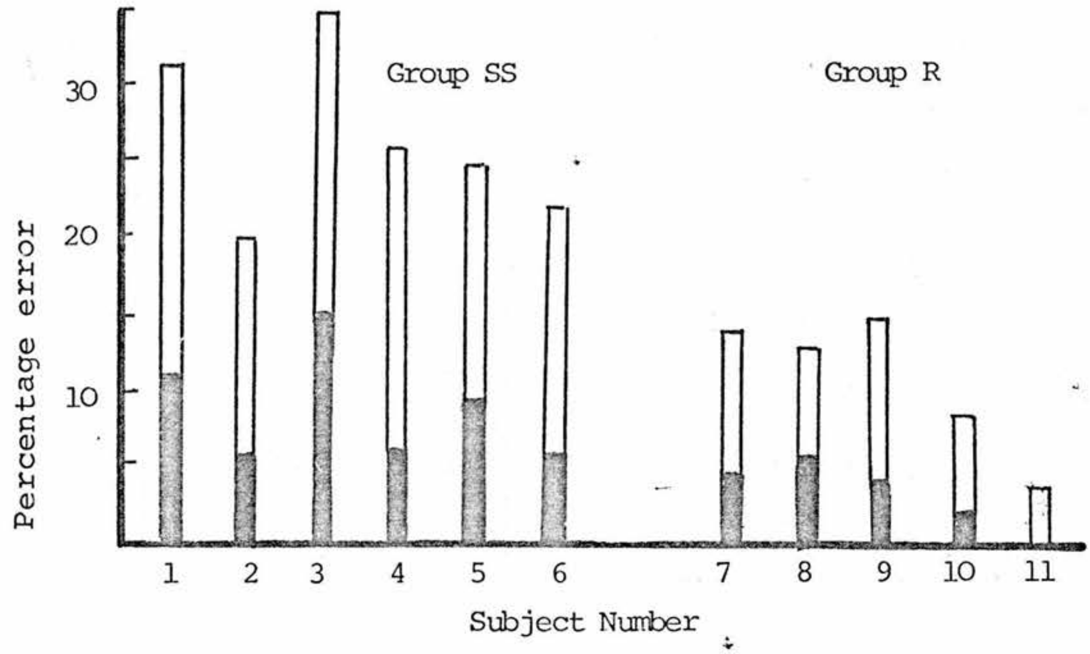


Figure 3 (2). Percentage error to small and large pair of training stimuli, for pre-Criterion 1 behaviour (above) and post-Criterion 1 behaviour (below), of Experiment 1 (2).

Note: The scale of the 2 histograms is different.

Rather than examine the performance of the two groups up to Criterion 2, this section examines the performance of the groups <u>after</u> they have reached Criterion 1, but before Criterion 2 has been met. This is essentially a 'stabilizing' period. However, the whole Criterion 1-to-2 period was not used in the inter-group comparison - rather, the <u>same</u> number of trials <u>after</u> Criterion 1 as each subject had taken to reach Criterion 1 was used. This was to enable the comparison between the groups during this stabilizing period to be related, more reasonably, to their pre-Criterion 1 performance. Table 2 (2) shows the performance of the two groups during this period, and can be compared with Table 1 (2).

Unlike the performance up to Criterion 1, a significant difference was found between the number of errors made during the stabilizing period, by the two groups. Group SS made significantly more errors than did Group R (t-test for independent measures - $t = 4.5$; $df = 9$; $p < 0.01$ for a two-tail test). Further, unlike the pre-Criterion 1 results both Group SS and Group R made significantly more errors to the larger stimulus-pair (B v C) than to the smaller (C v D), (t-test for related measures - Group SS: $t = 5.04$; $df = 5$; $p < 0.01$ for a two-tail test. Group R: $t = 5.26$; $df = 4$; $p < 0.01$ for a two-tail test). The appropriate histogram of Figure 3 (2) displays this information in a graphical manner, and a visual comparison can be made with the pre-Criterion 1 behaviour, represented also in this figure.

DISCUSSION

Clearly, both groups learned the discrimination. Further, they performed/

Group	Subs.	(Trials)	Errors		
			Total	Smaller pair-CD.	Larger pair-BC.
SS	1	(138)	31	12	19
	2	(110)	18	5	13
	3	(133)	34	16	18
	4	(86)	25	6	19
	5	(221)	24	9	15
	6	(105)	22	6	16
	Mean	(132)	26	9	17
R	7	(126)	14	4	10
	8	(132)	13	5	8
	9	(127)	15	3	12
	10	(141)	10	1	9
	11	(54)	4	0	4
	Mean	(116)	12	3	9

Table 2 (2). The performance of the 2 groups following Criterion 1, of Experiment 1 (2).

performed equally well during training up to what is most commonly used in experimental psychology (although, quite arbitrarily) as the criterion of acquisition for such discrimination tasks. This performance of the monkeys is in marked contrast to other analogous experiments carried out in the present laboratory with two other species. In collaboration with B.O. McGonigle and R. Osborne, rats were trained on a simultaneous size discrimination using a Jumping Stand and exactly the same stimuli and paradigm as used in Experiment 1 (2). No rat in the group comparable with Group SS of the current experiment reached criterion on the discrimination task even after 1,000 trials, whereas all the subjects of the group comparable with Group R, did. Further, in collaboration with B.O. McGonigle and R.J. Wales, young children were similarly trained using exactly the same paradigm and stimuli and a W.G.T.A. specially modified for their use, and the same superiority of the group comparable with Group R of Experiment 1 (2) was evident. The performance of the monkeys also deviates from other work, as well as the two studies reported above. Wolfle (1937), using rats and a similar paradigm, has shown that for brightness discriminations, a group comparable with Group R of the current experiment learns the discrimination much faster than a group comparable with Group SS. However, unlike the rat study from the present laboratory, both groups were successful in discriminating. In a study by Meyer (1964), designed to fully test Hull's Theorem 14 (Hull, 1952), rats in groups comparable to Group R and Group SS were included (Group IV, VI and Group III,V respectively - see Meyer 1964, Table 1), and the superiority of so-called relational over absolute learning was, again, demonstrated. As in the Wolfle study, however, the so-called absolute/

absolute group did eventually learn the discrimination. In Meyer's study, unlike that of Wolfle but like the rat study from the present laboratory, size discriminations were used, which makes the inability of the so-called absolute group from the latter experiment to learn the discrimination even more surprising (this point will be returned to later). In summary, the performance of the monkeys of the current experiment, in terms of the symmetry of behaviour of the groups, deviates from what is currently known.

The post-Criterion 1 performance, however, tells a different story, in that Group SS made many more errors than did Group R - which is more consistent with the studies using analogous paradigms, and reported above. These results are interesting in light of the hypothesis produced by Wertheimer (1959) - that it would be much harder for a subject to remember precise, absolute values of a stimulus than to remember only the direction of a relation, disregarding the absolute value of the relative difference between the stimuli. He writes (Wertheimer 1959, page 253):

"Memory (recall, recognition, etc.) for absolute qualities like absolute size, absolute pitch, is especially after a considerable time interval, pretty bad, vague and liable to be shifted by external influences . . . . . . Remembering the direction of relations is much easier than remembering their exact 'sizes' and absolute qualities."

The results of the post-Criterion 1 phase of Experiment 1 (2), and the other studies reported above, lend support to Wertheimer's hypothesis, and the results of the current experiment, as a whole, support the view that both so-called relational and absolute properties of the discriminanda/

discriminanda can be utilised in the control of behaviour.

However, the symmetry of the performance of Group R and SS up to Criterion 1 needs some explanation - whilst this may be consistent with the view that either absolute or relational properties may be used in the production and maintenance of choice behaviour, it is inconsistent with the position represented by Wertheimer. A feasible explanation of this discrepant result could lie in the fact that whatever (potential) differences may come to develop between the two groups would hardly be evident in their behaviour during the early stages of the discrimination training where subjects are performing largely at chance levels, and that this would tend to initially overshadow group differences should they begin to emerge (see, for example, the intraproblem data of Meyer 1964). It is suggested that the symmetry of the performance of the two groups up to Criterion 1 is the function of such an overshadowing effect. An examination of the distribution of errors between the stimulus pairs B v C and C v D during pre-Criterion 1 and 2 behaviour tends to support this conclusion. Errors were distributed equally between the two stimulus pairs by both groups before Criterion 1, whereas after Criterion 1, both groups made significantly more errors to stimulus pair B v C than to C v D, irrespective of the fact that both groups were being asked to learn different tasks. It seems reasonable to assume that the reason for the difference in the number of errors made to the different stimulus pairs in the result of pair B v C having single stimuli closer together than pair C v D on whatever continuum the subjects use for encoding 'size' (e.g. linear dimensions, surface area, volume). Even though/

though the different groups had been set different tasks, the problem that they would experience with B v C and with C v D would be a shared one. However, if in the early stages of discrimination training, both groups (learning different tasks) experienced a difficulty which was a function of the general procedure rather than their specific tasks, then not only should the number of errors made be relatively large (approximately 50% of the number of trials), but they should be equally distributed between both stimulus pairs for both groups - which is what the results show.

The results of Experiment 1 (2) indicate that whatever is learned by Group SS in learning the discrimination is relatively unstable when compared with whatever is learned by Group R, and is consistent with Wertheimer's formulation. If it is the case that whatever memory difficulty involved in remembering so-called absolute properties is increased with the passage of time, and if it is also the case that during this time interval the memory for so-called absolute properties is susceptible to 'external interference', then it should be possible to selectively affect the performance of Group SS with specially administered tests designed to interfere with the memory of specific stimulus values. The following experiment tests such a proposition.

EXPERIMENT 2 (2)

INTRODUCTION

In Experiment 1 (2) subjects of Group SS were trained to conserve the choice of a stimulus of invariant proportions from others of varying proportions, whereas Group R were trained to conserve a relationship between stimuli of varying proportions. The superiority of the performance of Group R over Group SS has been interpreted as supporting the general contention that the memory for so-called absolute or specific qualities is much less stable than for so-called relational qualities. Experiment 2 (2) is designed to determine whether or not such proposed differential stability in retention can be more directly measured, and demonstrated to be reliable under more controlled conditions of test.

The disruptive element used in the current experiment was not, simply, the passage of time (likely to be disruptive in itself, as in Experiment 1-2), but the introduction before choice trials of novel stimulus configurations for the subject to view - an instance of the 'external influences' of Wertheimer (1959, page 253). The prediction follows, from the position developed from the previous experiment, that the pre-exposure stimulus configurations should disrupt the retention of Group SS more than that of Group R.

METHOD

Subjects

The/

The eleven subjects that served in the previous experiment were used in this experiment, and retained in their respective groups.

Apparatus

The same W.G.T.A. was used as in the previous experiment, with the same matt-red, two-stimulus presentation tray. Lighting conditions were as before.

Stimuli

In addition to Stimulus B, C and D, Stimulus A and E were used in this experiment. The new stimulus were identical to B, C, and D in every respect except size: Stimulus A was a $2\frac{1}{2}$" cube and Stimulus E a $\frac{1}{2}$" cube.

Procedure and Design

Before subjects were allowed to begin Experiment 2 (2), they had to satisfy Criterion 2 of the previous experiment, i.e. they had to make no more than one error for three consecutive days, at thirty trials per day. It was essential that such a strict criterion be adopted before the onset of Experiment 2 (2), since disruptive effects anticipated could be quite small and might only be detectable against a very stable baseline of behaviour.

The procedure adopted was similar to the previous experiment, with the exception of the first four trials of the day. Prior to each one of these four trials, a pre-exposure trial was given, in which, for thirty seconds the subject was allowed to view a new stimulus configuration positioned on the stimulus tray which was just out of reach. This pre-exposure/

exposure configuration had, hitherto, never been associated with reward - nor, throughout this experiment, were they brought in reach of the subjects. Following this thirty second pre-exposure period, the opaque screen was lowered, the pre-exposure configuration was removed, and the pre-exposure trial was terminated. Immediately following the removal of the pre-exposure configuration, both the foodwells were baited and the relevant (see later) stimulus pair from the training trials (i.e. B v C or C v D) positioned on the tray and presented to the subject in the normal way, with a total delay from the termination of the previous pre-exposure trial of approximately three seconds - these were called the pre-exposure test trials. Following choice responding (with non-differential reward), the trial was terminated in the normal way and the usual fifteen second intertrial interval was interposed, before the beginning of the next pre-exposure trial. Each subject received, daily, four such pre-exposure trials and each one was followed by a non-differentially rewarded pre-exposure test trial - for four consecutive days.

Thus, each subject was given a total of sixteen pre-exposure trials (four per day for four days) with one of the four different pre-exposure stimulus configurations per day. The four pre-exposure stimulus configurations are shown in Figure 4 (2). They consisted of Stimulus A, A v B v C, E and C v D v E. Single stimuli were positioned in the centre of the tray and the stimulus-triads with the middle stimulus in the centre and the two remaining stimuli at $\frac{1}{2}$" distance to either side, in a step-wise (size) progression. The later-ability of this progression was balanced for the four pre-exposure trials, of those days in which the pre-exposure configurations was a triad. The day-to-day order of presentation/

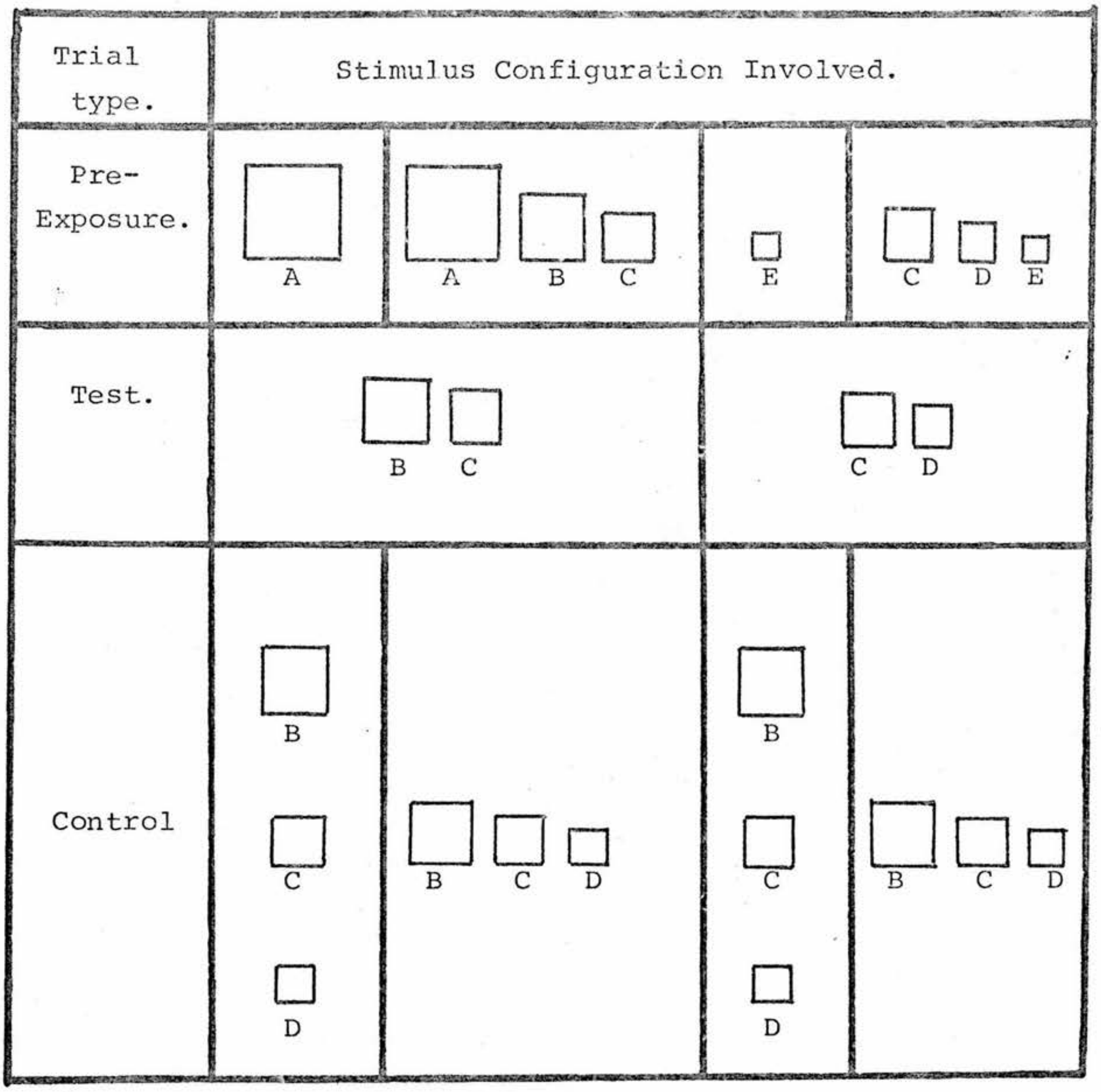


Figure 4 (2). The corresponding stimulus configurations used on each of the trial-types of Experiment 2 (2).

Note: The configurations for the training trials are excluded.

presentation of the pre-exposure configurations was partially counter-balanced within each group using the same 4 x 4 Latin Square, repeating one row for Group R and two rows for Group SS (since n=5 and n=6 for each group, respectively). Consequently, in terms of order of presentation, every subject in Group R was matched by a subject in Group SS (with one subject of Group SS left unmatched). The laterality of the triads was, also, matched between groups. The effects of the pre-exposure stimulus configurations A and A v B v C upon the retention of the discrimination training of Experiment 1, was tested with training pair B v C; and the effects of E and C v D v E with C v D (see Figure 4-2) - the rationale for which is contained in the discussion of the current experiment. During the four pre-exposure test trials, the laterality of the test stimuli was balanced. It should be noted that during the pre-exposure trials and the subsequent test trials, both groups were treated in the <u>same</u> way.

Following these daily trials, thirty differentially rewarded training trials were given, in exactly the same way as in Experiment 1 (2), with stimulus pairs B v C and C v D. However, if, in any of these daily pre-exposure test trials, a disruption was evident (i.e. a subject's response which deviated from what would be expected on the basis of the discrimination training received in the previous experiment), then the first ten of the thirty training trials for that day were preceded by a control, pre-exposure period with either Stimulus B, C, D or B v C v D. If the pre-exposure stimulus was A or E, then the control configuration was B, C or D, presented alone and in a random order; if A v B v C or C v D v E, then B v D v D was used.

To start the next day's testing, subjects were allowed to make no more than/

than one error during the last twenty trials (i.e. normal training trials) of the day.

RESULTS

A 'shift' was recorded whenever a subject deviated from responding, during the pre-exposure test trials, to that stimulus for which he would have normally been rewarded for responding to in Experiment 1 (2), i.e. his 'positive' stimulus, and also in the normal training trials of the current experiment. This could also have been called an 'error' (since, operationally, this is what it was), but since the subject would not experience the normal 'error' conditions, in that the trials were non-differentially rewarded, the term 'shift' was preferred.

The overall effect of the Pre-Exposure Trials on the groups

Table 3 (2) records the number of shifts made per day for the four days of testing, during the pre-exposure test trials of both groups. Throughout the four days of testing, Group SS made significantly more shifts than did Group R (t - test for independent measures, performed on the total number of shifts per subject, derived from Table 3-2 - $t = 6.438$; $df = 9$; $p < 0.001$ for a two-tail test). No subject of Group R showed more shifts than any subjects of Group SS - in fact, the most disrupted subject of Group R displayed exactly half as many shifts as the least disrupted subject of Group SS. The performance of Group R was hardly affected during the test trials: each subject still maintained significant choice behaviour, at least, at the 1% level (Binomial/

Group	Subject	Days of Testing				
		1	2	3	4	Total
SS	1	1	3	0	0	4
	2	4	2	2	1	9
	3	2	1	2	0	5
	4	2	0	2	3	7
	5	2	3	1	1	7
	6	2	2	0	2	6
	Total	13	11	7	7	38
	Mean	2	2	1	1	6
R	7	0	0	0	0	0
	8	1	0	0	0	1
	9	0	1	0	0	1
	10	0	0	0	1	1
	11	0	0	0	0	0
	Total	1	1	0	2	4
	Mean	0	0	0	0	1

Table 3 (2). The number of 'shifts' recorded for each subject during the Pre-exposure test trials on each of the 4 days of testing, of Experiment 2 (2).

Note: The means are rounded off to the nearest integer.

(Binomial test where $p = q = \frac{1}{2}$, performed on the totals of Table 3-2 - all p-values greater than 0.01 for a two-tail test). No subject of Group SS maintained significant choice behaviour during the pre-exposure test trials, which indicates that the performance of Group SS was severely disrupted (Binomial test - p-values ranging from 0.38 to 0.98 for two-tail tests).

<u>A more detailed analysis of the performance of both groups</u>

The performance of each group during the pre-exposure test trials was also compared with each group's baseline behaviour and its behaviour whilst recovering from the pre-exposure trials. Before this, however, a straight comparison between the two groups was made for periods which represent baseline, experimental and control periods. In fact, the behaviour in the four periods was compared. The four periods were defined as follows (refer to Figure 6-2):

A. <u>Period 1</u>. This was taken as an indication of baseline behaviour of each group, and consisted of those four normal, differentially-rewarded training trials (with stimulus pairs B v C and C v D) immediately preceding the four daily pre-exposure trials and tests; or, the last four trials of the previous day. It had already been established whilst running Experiment 1 (2) that in the final days of testing, the behaviour during the last trials of the day did not differ from the behaviour of the first trials of the day following.

B. <u>Period 2</u>. This was the 'experimental' period and was the daily pre-exposure test trials.

C. <u>Period 3</u>. This was a control period, and taken as the period of four/

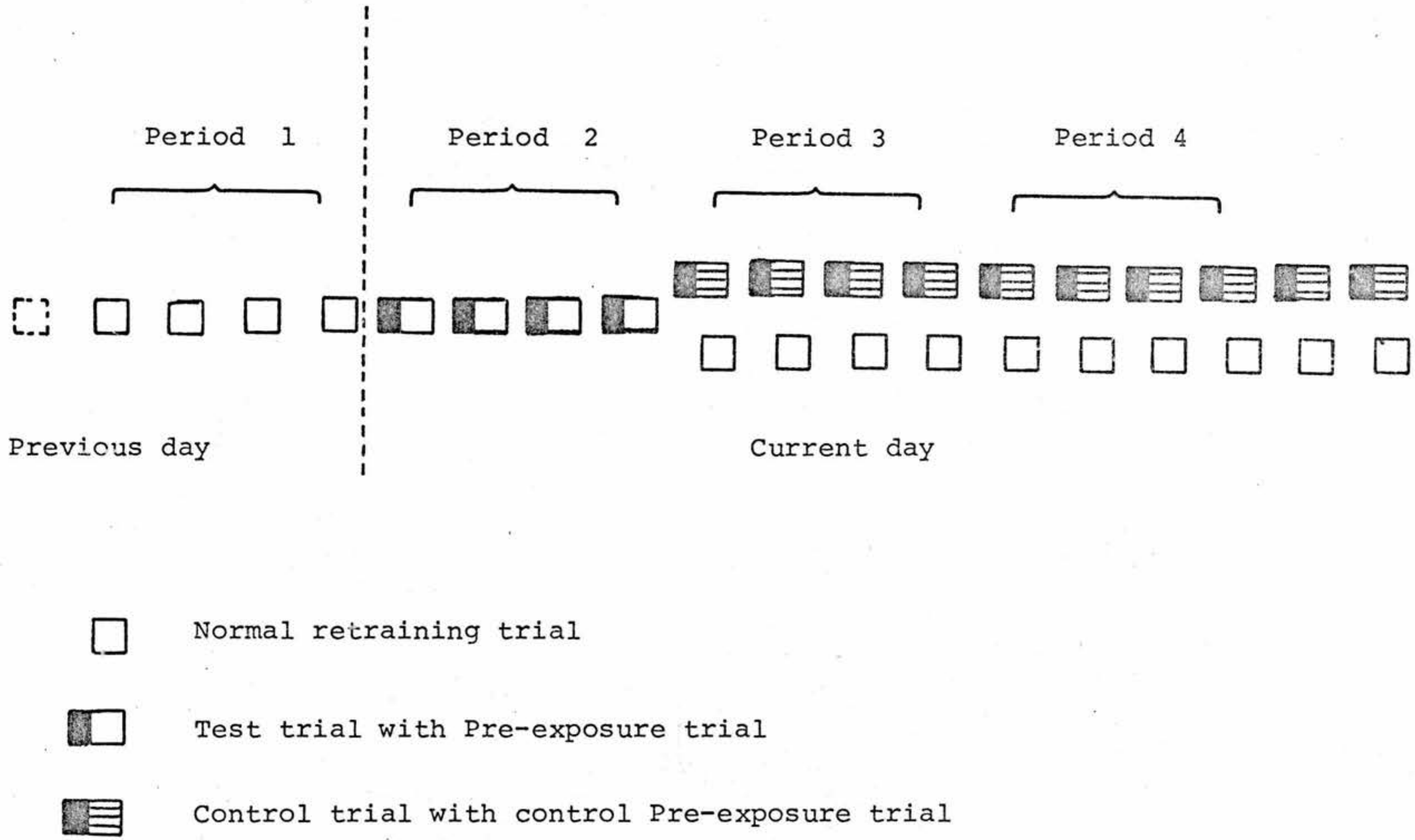


Figure 6 (2). The relationship between the 4 Periods of Experiment 2(2).

four trials immediately following the pre-exposure session during which time, control pre-exposure trials were given where appropriate.

D. Period 4. This was identical to Period 3, but consisted of the next four trials, preceded by control pre-exposure trials, where appropriate.

A comparison of the performance of the two groups, period-by-period

For each of the four periods, the data from the four days of testing was combined. Figure 6 (2) records the relationship between the periods. Table 4 (2) records the number of shifts occurring during each period (combined over the four days) for both groups, and the histogram of Figure 7 (2) displays this graphically. Visual inspection of both table and histogram clearly indicates that during Period 1, there was no difference between the groups. In fact, their baseline behaviour was both identical and perfect. During Period 2, however, the baseline behaviour of Group SS is severely disrupted, whereas that of Group R is hardly affected. During Period 3, the behaviour of Group R remains stable, but whereas the behaviour of Group SS remains disrupted, it is much less so. Finally, in Period 4, the difference between the groups is much reduced. The Mann-Whitney U-test was used to compare the performance of the two groups with each other in each of the four periods. However, since the chances of obtaining a significant U are increased fourfold by carrying out such repeated comparisons on the two groups, the table-derived level of significance associated with a particular U needs to be quadrupled to derive the practical level of significance (e.g. see Langley, 1968, page 213). Using/

Group	Subject	Period			
		1	2	3	4
SS	1	0	4	3	0
	2	0	9	4	2
	3	0	5	3	1
	4	0	7	6	2
	5	0	7	3	1
	6	0	6	4	2
	Total	0	38	23	8
	Mean	0	6	4	1
R	7	0	0	0	0
	8	0	2	0	0
	9	0	1	0	0
	10	0	1	0	0
	11	0	0	1	0
	Total	0	4	1	0
	Mean	0	1	0	0

Table 4 (2). The number of 'shifts' recorded for each subject during the 4 Periods of Experiment 2 (2).

Note: The means are rounded off to the nearest integer.

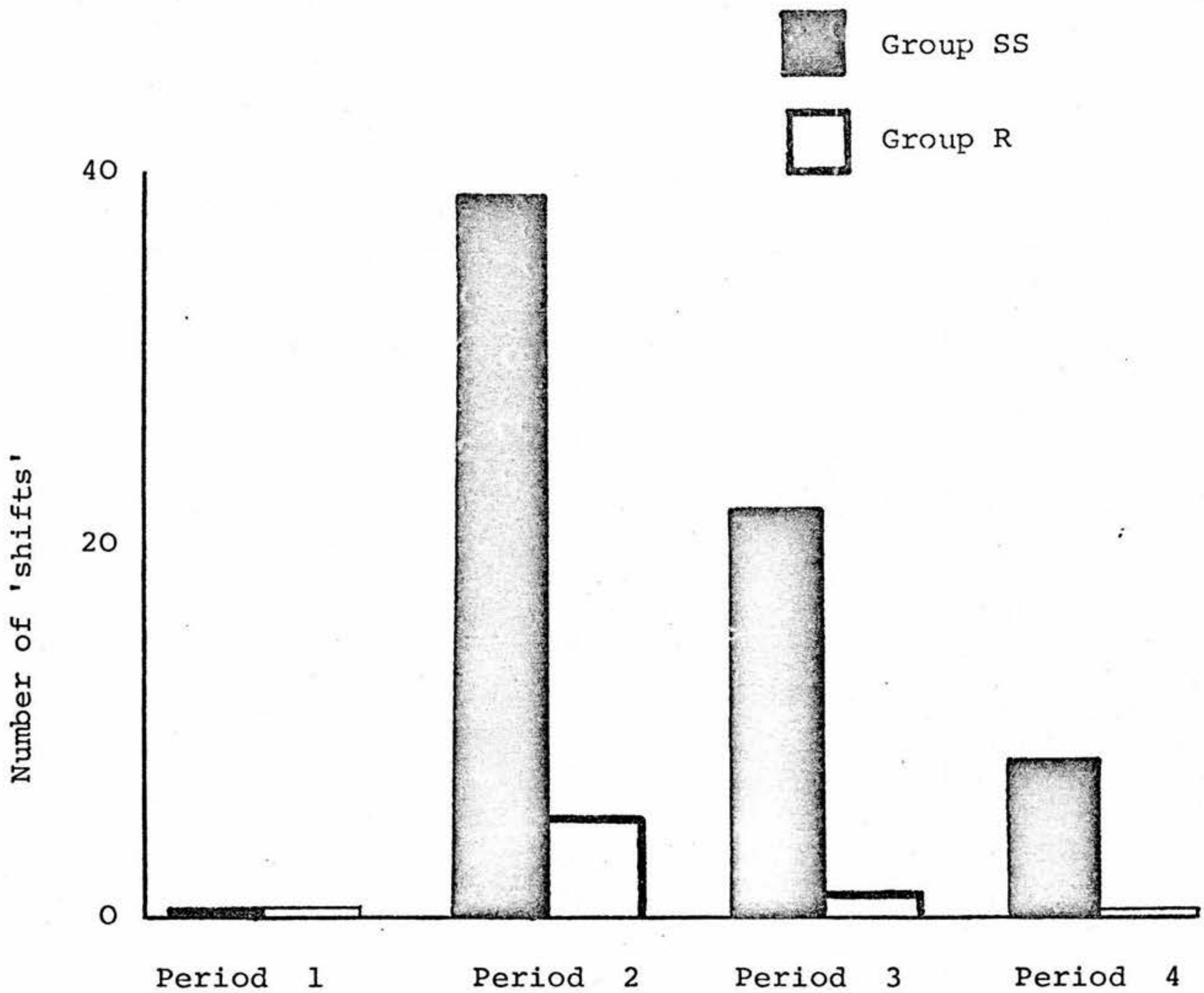


Figure 7 (2). The total number of 'shifts' recorded for each group during the testing periods of Experiment 2 (2).

Using such statistical procedures, significant differences were found between the groups during Period 2 and Period 3 ($U = 0$; $n1 = 5$; $n2 = 6$; practical $p < 0.008$ for a two-tail test for both periods), although the difference was much reduced during Period 3. For Period 4, the difference was not significant ($U = 2.5$; $n1 = 5$; $n2 = 6$; practical $p > 0.1$ for a two-tail test). For Period 1, there were no differences between the individual scores of the group members and, therefore, a statistical test proves to be unnecessary.

A comparison of the performance between periods, group-by-group

The performance of each group, alone, was compared in each of the four periods - i.e. the behaviour during the pre-exposure test trials (Period 2) was compared with the baseline behaviour (Period 1) and the two control periods (Periods 3 and 4), for each group, seperately. Analysis of variance indicated that the difference between, at least, one pair of periods was significant for Group SS (Friedman's Analysis of Variance performed on the data of Table 4 (2) - Friedman's chi-square = 17.45; $k = 4$; $n = 6$; $p < 0.001$). Interpretation of this significant statistic was achieved using a test specifically designed to meaningfully carry out all possible pair-wise comparisons without artificially increasing the chance of erroneously obtaining significance (as outlined above), (see Langley, 1968, page 227). Table 5 (2) contains the results of the six possible comparisons between the periods for Group SS. As the table shows, significant differences for Group SS were located between Periods 1 and 2 ($p < 0.001$), Periods 1 and 3 ($p = 0.05$) and Periods 2 and 4 ($p < 0.05$). The other comparisons were not significant. Thus, in Periods 2 and 3, Group SS were significantly disrupted from the baseline behaviour as indicated by Period 1 - and, by/

Periods Compared	F-value	p-value
1 - 2	7.14	<0.01
1 - 3	4.70	<0.05
1 - 4	2.04	ns
2 - 3	2.45	ns
2 - 4	5.10	<0.05
3 - 4	2.65	ns

Table 5 (2). Inter-period comparisons carried out following a significant F, denoting the existence of differences between the number of 'shifts' recorded in the 4 Periods of Experiment 2 (2).

Note: The good approximation to the F-statistic is obtained from the following formula (Langley 1968, page 227):

$$F = d/(n)^{\frac{1}{2}}$$

where d = difference between the rank totals of the 2 samples being compared (derived from the tabular part of the non-parametric analysis of variance.)

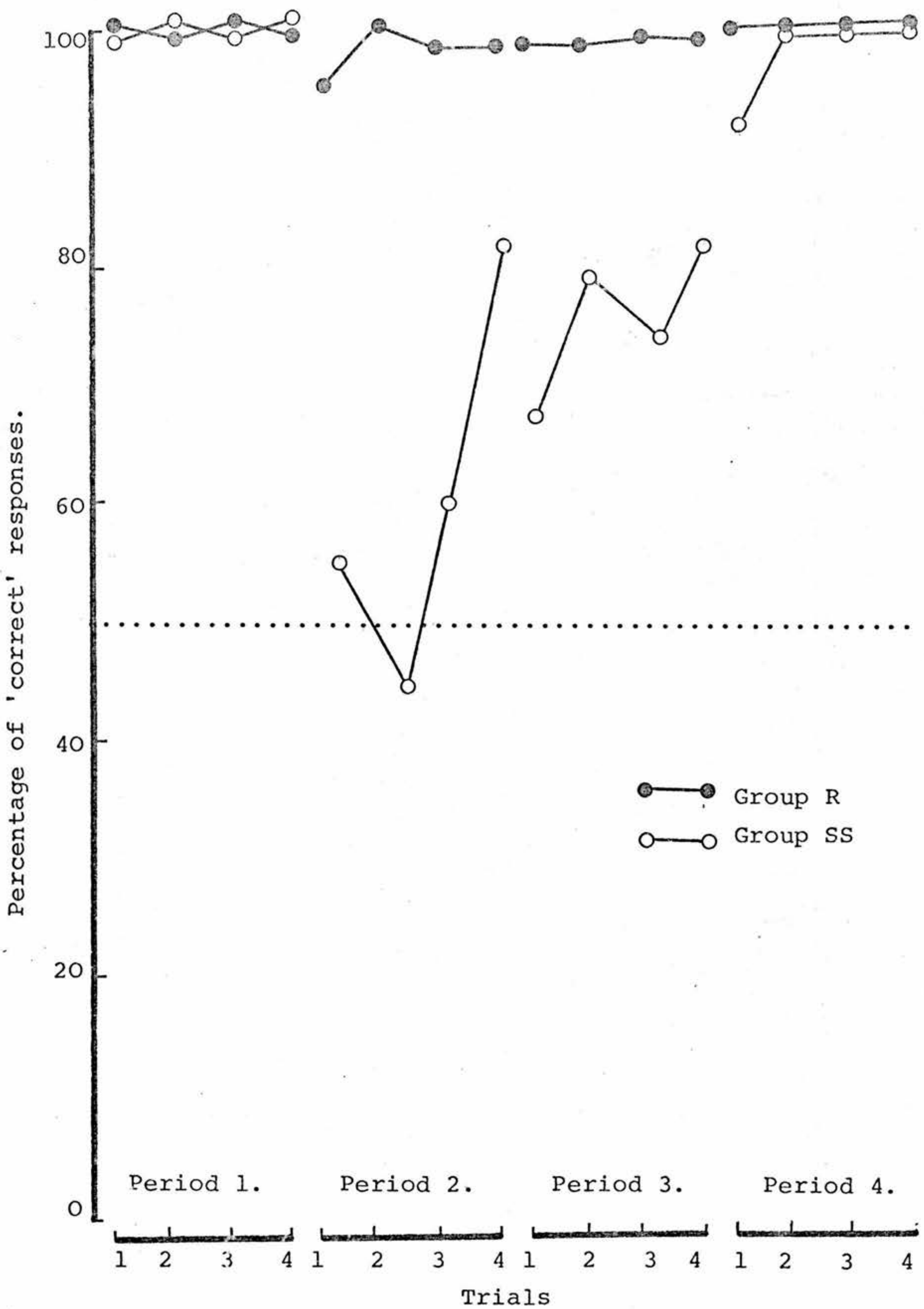
where n = the number of measurements in each sample.

by Period 4 had been reached, had sufficiently recovered to be equivalent to Period 1 and different from Period 2. A more detailed description of the period-by-period performance than is given in Figure 7 (2) is given in Figure 8 (2), which displays the performance in each period for the two groups in terms of percentage 'correct' on each trials within the periods (i.e. percentage of trials on which shifts were not observed). This permits of clearer interpretation of the comparisons referred to, above. A similar analysis of variance was not carried out for Group R, since inspection of Table 4 (2), Figures 7 (2) and 8 (2), indicates that there is no possibility of obtaining a significant Friedman's chi-square. That is to say, the behaviour of Group R from period to period is relatively invariant.

Since the behaviour of Group R raises few questions at this point, the following analysis is only carried out on the subjects of Group SS. This takes the form of an analysis of the effects of the difference pre-exposure stimulus configurations, the different daily test trials, and the different days of testing upon the so-called shift behaviour.

1. Pre-exposure stimulus configurations and shift behaviour

Table 6 (2) records the number of shifts made during the test trials, following the pre-exposure trials, for Group SS (the performance of Group R is also recorded for completeness). Clearly, considerably more shifts are elicited by stimulus configuration E than any other - the remaining three configurations eliciting approximately the same number of shifts. A Treatments-by-Subjects Analysis of Variance or a Repeated Measures Design (Winer 1962, page 105) on the data of Table 6 (2), shows there are significant differences/



<u>Figure 8 (2).</u> <u>The percentage of correct responses made on each of the test trials of the 4 Periods of Experiment 2(2).</u>

Group	Subject	Pre-exposure Stimulus Configuration				
		A	ABC	E	CDE	Combined
SS	1	0	1	3	0	
	2	2	2	4	1	9
	3	2	0	2	1	5
	4	2	0	3	2	7
	5	2	1	3	1	7
	6	0	2	2	2	6
	Total	8	6	17	7	38
R	7	0	0	0	0	0
	8	1	1	0	0	2
	9	0	0	0	1	1
	10	0	0	1	0	1
	11	0	0	0	0	0
	Total	1	1	1	1	4

Table 6 (2). The number of 'shifts' recorded for each subject on the test trials following pre-exposure trials with each of the 4 pre-exposure configurations in Experiment 2 (2).

differences between the stimuli in their ability to elicit shifts ($F = 5.75$; df = 3,15; $p < 0.01$; see Table 7 (2) for Source Table). The location of the difference(s) was determined using a t-test for Differences Among Several Means (Bruning and Kintz, 1968, page 112). Comparisons between Stimulus E and the other three configurations did reach significance ($p < 0.01$). No other comparison did reach significance ($p > 0.1$). Thus pre-exposure Stimulus E was significantly better at eliciting shifts than any other configuration. However, this is not to say that the other stimulus configurations were ineffective, as an inspection of Table 6 (2) will confirm.

2. Pre-exposure days and shift behaviour

Table 3 (2) records the daily total of shifts for each subject during the four days of pre-exposure testing. Behaviour is collapsed or combined across daily trials and the different pre-exposure configurations. A Treatment-by-Subjects Analysis of Variance showed that there was no significant difference between the four days of testing in the number of shifts produced ($F = 1.154$; df = 3,15; $p < 0.2$; see Table 9 (2) for Source Table). Although five out of six subjects of Group SS made more shifts during the first two days than the second two days, this difference failed to reach significance (t-test for related measures - $t = 1.48$; df = 5; $p < 0.1$ for a two-tailed test).

3. Daily pre-exposure trials and shift behaviour

Table 10 (2) shows the number of shifts for each subject of the two groups combined or collapsed across stimulus configurations and/

Source	SS	*DF*	MS	*F*	*p*
Total	27.83	23	-	-	-
Subjects	3.83	5	-	-	-
Configs	12.83	3	4.28	5.75	<0.01
Error	11.17	15	0.79	-	-

Table 7 (2). Source Table of the variance contributed by Subjects and Configurations during the responding on pre-exposure test trials of Experiment 2 (2).

Source	SS	*DF*	MS	*F*	*p*
Total	27.84	23	-	-	-
Subjects	3.84	5	-	-	-
Day	4.50	3	1.50	1.15	>0.2
Error	19.50	15	1.30	-	-

Table 9 (2). Source of the variation contributed by Subjects and Day-number during responding on the pre-exposure test trials of Experiment 2 (2), for Group SS.

Group	Subject	Pre-exposure Trial				
		1	2	3	4	Combined
SS	1	0	1	2	1	4
	2	2	3	3	1	9
	3	3	1	1	0	5
	4	3	3	1	0	7
	5	1	3	2	1	7
	6	3	2	1	1	6
	Total	11	13	10	4	38
	Mean	2	2	2	1	6
R	7	0	0	0	0	0
	8	1	0	0	0	1
	9	0	0	1	0	1
	10	1	0	0	0	1
	11	0	0	0	0	0
	Total	2	0	1	1	4
	Mean	0	0	0	0	0

Table 10 (2). The number of 'shifts' recorded for each subject on each of the daily test trials following the pre-exposure trials of Experiment 2 (2).

Note: The means are rounded off to the nearest integer.

and days of testing, and grouped according to daily trial number. Again, a Treatments-by-Subjects Analysis of Variance was used on the data of Group SS (derived from Table 10-2), and showed that there was no significant difference between the position (i.e. 1 to 4) of the trial and the number of shifts observed ($F = 3.0$; $df = 3,15$; $p > 0.1$; see Table 11 (2) for Source Table). As in the previous section dealing with days of testing, more shifts were made by five out of six subjects of Group SS during trials one and two than during trials three and four, but this was not significant (t-test for related measures - $t = 1.59$; $df = 5$; $p > 0.1$ for a two-tail test).

DISCUSSION

The results of Experiment 2 (2) are in close agreement with those of Experiment 1 (2), in that the choice behaviour of Group SS is disrupted to a considerably greater extent than that of Group R. This provides further, more detailed, support for the contention that retention of the so-called absolute qualities of stimuli is much more difficult than the retention of so-called relational qualities - and Experiment 2 (2) demonstrates that a specific source of external interference can differentially effect the performance of the two groups.

However, a more detailed analysis of the results indicates that Group SS does not, merely, have its choice behaviour disrupted significantly more than that of Group R - but that the choice behaviour of Group SS is reduced to chance responding, itself, whereas that of Group R is not significantly affected. Further, the period-by-period analysis of the/

Source	SS	*DF*	MS	*F*	*p*
Total	23.84	23	-	-	-
Subjects	3.83	5	-	-	-
Trial	7.50	3	2.50	3.00	>0.1
Error	12.50	15	0.84	-	-

Table 11 (2). Source of the variance contributed by Subjects and Trial-number during responding on pre-exposure test trials of Experiment 2 (2) for Group SS.

the results demonstrates that this disruptive effect evident in the behaviour of Group SS during the pre-exposure test trials is not a function of the testing procedure, itself; otherwise the performance during the last control period would display significant disruption, and it does not. The fact that Group R, although treated in a similar manner to Group SS, shows minimal disruption, supports this view.

Not only does the position of Wertheimer (1959) gain support from Experiment 2 (2), but also that of Helson (1938, 1964 and 1973), interpreted and adapted for use in discrimination learning situations by H. James (1953) and Zeiler (1963) - it was not the intended purpose of the current experiment to put any aspect of Helson's adaptation-level theory to the test, but the design and results of the experiment lend themselves to this, as a bonus. According to Helson's theory, the sensation aroused by any stimulus is determined by some difference between it and some internal referent. This referent is the adaptation-level and is produced or derived by a 'stimulus pooling' process, and best estimated by a weighted geometric mean of past and present stimuli in whatever category is being considered. The adaptation-level has the status of a perceptual neutral or a point of indifference - for example, sizes above the perceptual neutral would be classed as 'big', whilst those below would be classed as 'small'. In Experiment 2 (2), the training stimuli (i.e. pairs B v C and C v D) can be regarded as the past stimuli and the pre-exposure configurations as the present stimuli - and it should be possible to predict how the adaptation level changes with such pre-exposure and predict subsequent choice performance.

There/

There are, however, many imponderables - for example, the relative weighting of each class of stimulus (e.g. past and present) contributing to the adaptation-level, and the time course with which the adaptation-level changes. Zeiler (1963) has attempted to estimate such, and other, parameters in size discrimination experiments (using data from earlier size discrimination experiments - Spence 1942; Gonzalez, Gentry and Bitterman 1959; Stevenson and Bitterman 1955; Gentry, Overall and Brown 1959; Brown, Overall and Gentry 1959), with apparent predictive success. However, as Riley (1968, page 90) has indicated, the test experiments of Zeiler were similar enough to those experiments from which the parameter values were derived, as to cause little surprise by their success in confirming the predictions made. It appears that with sufficient juggling of parameter values (and a rationale can usually be found for any arrangement of parameter values - for example, H. James 1953, pages 347 and 348) most data can be accommodated. Nevertheless, if it is assumed that at the completion of Experiment 1 (2) the adaptation-level is stabilized and a function of the stimulus pool, alone, (with which there has been massive experience) and if it is further assumed that upon pre-exposure (i.e. thirty seconds) a new adaptation level is temporarily created which is the mean of the previous one and the pre-exposure configuration, then some basis for the predicting of changes in choice behaviour develop - albeit, post hoc. A further assumption that need be made is that the stimuli presented to test choice behaviour immediately following pre-exposure trials do not influence the current adaptation-level - a reasonable assumption, in that responses are usually made within a couple of seconds. If Zeiler's lead is followed in defining the stimulus/

stimulus (the ratio of its value to the adaptation-level) then calculations indicate that the rank order of 'effectiveness' in shifting the adaptation-level in pre-exposure trials is stimulus configuration E, A, EDC and ABC; and, further, the adaptation-level is shifted considerably by Stimulus E and much less so by A, EDC and ABC. Since pre-exposure with configurations A and ABC would shift the adaptation-level towards the "A-end" of the continuum, and pre-exposure with configurations E and EDC towards the "E-end", tests for changes in choice behaviour would need to be carried out with pair B v C for pre-exposure configurations A and ABC, and with C v D for E and EDC. This was the decision made with respect to the test pairs, in designing Experiment 2 (2), but for reasons less formal than those supplied by adaptation level theory.

Inspection of Table 6 (2) indicates that the rank order of effectiveness of the pre-exposure configurations in producing shifts of choice behaviour is the same as that predicted by adaptation-level theory for the effectiveness of shifting the adaptation-level. The analysis also indicates that Stimulus E is significantly better at eliciting shifts than the others, and lends further support to adaptation-level theory. However, it could be argued that the difference in effectiveness between the pre-exposure configurations represent differences in their ability to 'catch the subject's attention'. The results of Experiment 1 (2) have already suggested that the interval between Stimulus D and C is larger than between B and C - and, if this is the case, then Stimulus E may be seen as more 'novel' than A and therefore more able to 'catch attention', and thus affect whatever is defining the subject's positive stimulus to a greater degree. Further, since the subjects are/

are more used to stimulus groups on the tray rather than single stimuli, both ABC and EDC would be relatively poor at 'catching attention' and, hence, less effective. The trend to progressively less shifts in choice behaviour both in the day's testing and through the four testing sessions could reflect such a decrease in ability to capture attention, which would influence to the same (reducing) degree whatever internal referent was being used for defining a stimulus.

Support, then, is gained from the current experiment for Wertheimer's position with respect to external influences producing differential effects for so-called absolute and relational retentions, and the results in general are consistent with what adaptation-level theory would predict. In view of what was discussed in Chapter 1 with respect to the logical impossibility of 'absolute' stimuli and the ultimate necessity of relating specific stimulus values to some referent, the theoretical positions of both Wertheimer and Helson can be conveniently related. Whilst Wertheimer propounds a system of explanation which, in his terms, puts the encoding of specific stimulus values in a vulnerable position, Helson propounds a system in which such encoding processes are seen in relation to an (internal) referent - producing a rationale for the observed instability and placing it within the types of explanations advocated in Chapter 1.

E X P E R I M E N T 3 (2)

INTRODUCTION

The two previous experiments suggest that the groups in the current series of size discrimination experiments have learned the discrimination in different ways which appear to differ in stability of retention. It has, further, been suggested that Group R have used so-called relational cues, whereas Group SS have used so-called absolute cues - and the results of Experiment 1 (2) and Experiment 2 (2) and their compatibility with the theoretical positions of Wertheimer and Helson offer nothing to disconfirm this view. Experiment 3 (2) is designed to determine the ability of the two groups to generalize whatever they have learned in Experiment 1 (2) to novel situations. Some of the generalization tests used as novel situations resemble one-step transposition testing of more conventional two-stimulus discrimination training.

METHOD

Subjects

The eleven subjects of the previous two experiments served as subjects, still being retained in their original groups. They were kept under the same conditions of maintenance.

Apparatus

The/

The same W.G.T.A. was used, as before, with the matt-red, two-stimulus tray.

Stimuli

In addition to the stimuli used in the original discrimination training of Experiment 1 (2), Stimulus A and Stimulus E was used. As in the previous two experiments, the normal, white versions were used.

Procedure and Design

The first ten trials of each daily session of the current experiment were run in accordance with the procedure of Experiment 1 (2). That is, ten normal differentially-rewarded training trials were given with stimulus pairs B v C and C v D alternating in a pre-determined, quasi-random sequence, such that each pair was presented five times during the sequence. Following these ten training trials, an experimental session of twenty trials was presented to each of the two groups.

Subjects in both groups were allowed to make no more than one error during these ten training trials. Should such a situation arise, then the day would continue not with the experimental session, but with a further twenty training trials conducted in the same way as the first ten trials of the day. Subjects requiring such retraining were retrained until they reached a criterion of no more than one error per daily training session (thirty trials). They were then allowed to continue into Experiment three (2), proper.

The twenty trials of the daily experimental session consisted of fifteen test trials and five randomly interpolated training trials. There/

There were two such experimental sessions, administered on consecutive days, producing a total of thirty test trials and ten interpolated training trials. The interpolated training trials were conducted with the procedure of Experiment 1 (2) - B v C and C v D and differential reward. The test trials of the experimental sessions were conducted in the same way except for the fact that the subjects responses were non-differentially rewarded and that one of three novel stimulus pairs covered the foodwells instead of either stimulus pairs B v C and C v D. The stimulus pairs used in these equivalence test trials were either A v B, B v D, or D v E (see Figure 8-2). All subjects of both groups received each of these three stimulus pairs, five times in each of the two experimental sessions. That is, each stimulus pair was presented to each subject a total of ten times during Experiment 3 (2). In any one session, the presentation of the test stimuli (fifteen trials) and the interpolated training stimuli (five trials) was random, and the laterality of the pairs was determined, as before. The interpolated training trials served to meter the performance of the subjects during the test sessions and check for any disruption of choice behaviour which could possibly occur.

RESULTS

The interpolated training trials indicated that the retention of the discrimination was not affected by the testing procedure. Table 12 (2) displays the performance of each subject on the 'generalization' tests for each stimulus pair. The table clearly indicates that each subject of Group R has responded to the larger of each of the stimulus pairs - the/

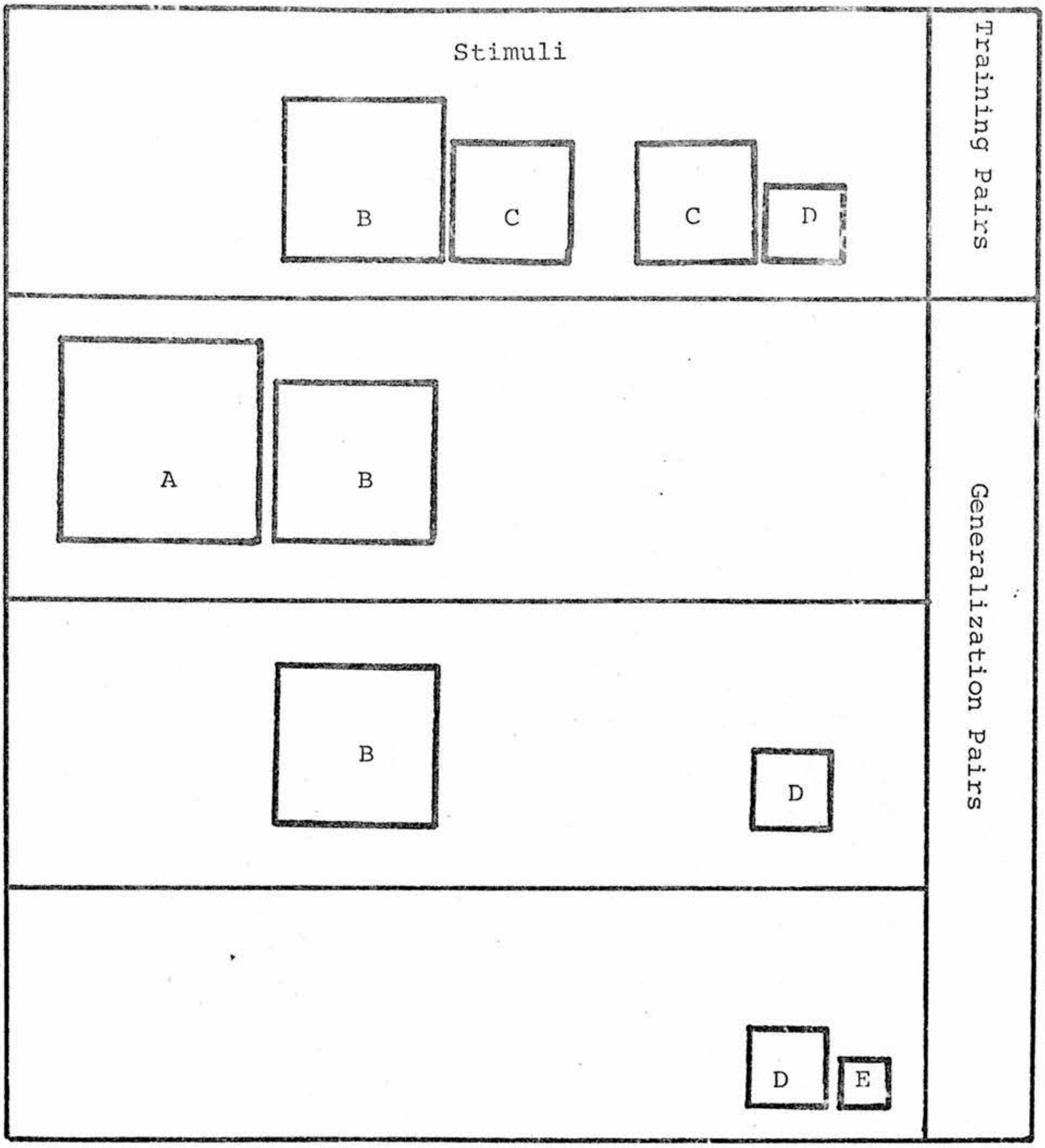


Figure 8 (2). The relationship between the stimuli of the generalization pairs and the stimuli of the training pairs.

Group	Subject	Generalization Pairs					
		A	B	B	D	D	E
SS	1	0	10	4	6	10	0
	2	0	10	4	6	10	0
	3	1	9	6	4	10	0
	4	2	8	7	3	9	1
	5	1	9	2	8	9	1
	6	0	10	5	5	10	0
	Total	4	56	28	36	58	2
R	7	6	4	10	0	8	2
	8	10	0	10	0	10	0
	9	10	0	10	0	9	1
	10	9	1	9	1	9	1
	11	10	0	10	0	9	1
	Total	45	5	49	1	45	5

Table 12 (2). The distribution of responses on each of the generalization pairs of Experiment 3 (2).

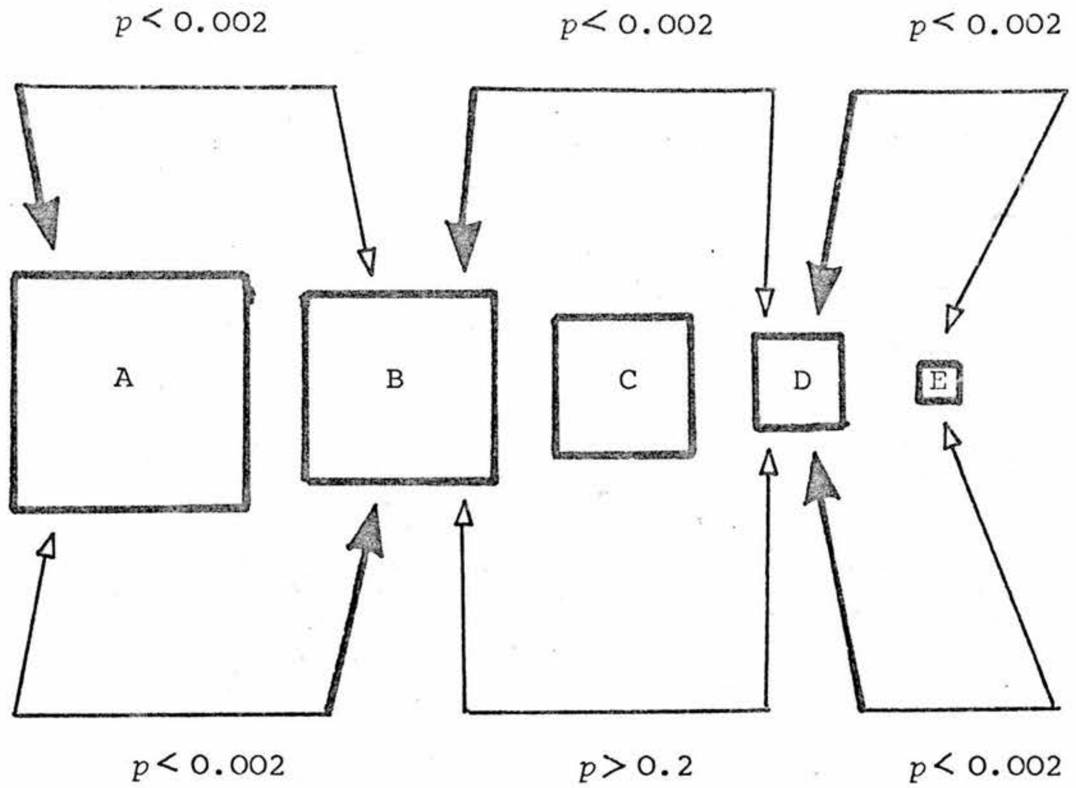
the preference is very strong and significant (Binomial test where $p = q = \frac{1}{2}$ carried out on the combined data for the group - $p < 0.002$ for a two-tail test for each of the three stimulus pairs). Table 12 (2) indicates that a choice bias is only shown by Group SS for stimulus pairs A v B and D v E, the stimuli of pair B v D being chosen equally often. Further, the choice bias in both cases indicates a preference for the stimulus which most resembles Stimulus C (the positive stimulus of this group), and these choice biases are significant (Binomial test, as above, carried out on data for the group - $p < 0.002$ for a two-tail test for pair A v B and D v E). Figure 9 (2) illustrates these results for the two groups.

DISCUSSION

The rule acquired by Group R during discrimination training is, clearly, applied in the three novel situations of Experiment 3 (2) - even in pair D v E where a stimulus previously negatively correlated with reward was consistently chosen. Using 'classical' terminology, Group R exhibited transposition behaviour. Group SS, on the other hand, only transfer choice behaviour to the two stimulus pairs equivalent to the classical one-step transposition pairs - and in the'classical' terminology, they exhibit absolute responding. With stimulus pair B v D, however, their choice behaviour breaks down.

The above results are highly consistent with the view that Group R has learned about a relationship between simultaneously presented stimuli (i.e. the larger is correlated with reward), whereas Group SS has learned about the specific characteristics of a single stimuli.

Group R.



Group SS.

Figure 9 (2). The choice bias showed by subjects on the Generalization tests of Experiment 3 (2).

Note: The actual stimulus pairs presented are linked by the arrows. The preferred stimulus is indicated by the more solid arrow, and the associated *p*-value is also shown.

EXPERIMENT 4 (2)

INTRODUCTION

The reward contingencies of the three previous experiments require one group of subjects to conserve a relationship between stimuli differing in 'size', and the other group to conserve a stimulus of invariant proportions. There are potentially many attributes of a stimulus that a subject could use in the recognition of its 'size'. Indeed, Piaget (1961) suggests that at one point in the development of a child's perception, the 'Taller is Bigger' is employed in the judgement of size. The opportunity is taken in the current experiment to investigate such a parameter in the squirrel monkey's commerce with stimuli differing in 'size'.

METHOD

Subjects

Only six subjects of the previous experiment took part in Experiment 4 (2). Subject ten and eleven (of Group R) were withdrawn from the series of experiments due to illness and subsequently died, reducing the size of Group R to three, permanently. Subjects four, five and six (of Group SS) did not take part in the current experiment, either. Thus, in Experiment 4 (2), Group R was represented by Subjects seven, eight and nine and Group SS by Subjects one, two and three.

Apparatus

The/

The W.G.T.A. and stimulus tray was the same as those used in the previous experiments reported in this chapter.

Stimuli

The basis training stimulus pool was used (i.e. Stimulus B, C and D) with the normal white cuboid versions. Two additional stimulus pools were constructed specifically for Experiment 4 (2) - test stimulus pools - in which modified versions of the basic training stimuli were made. Three types of modifications were carried out, to the physical dimensions of the stimuli, and were made with reference to each of the two pairs of stimuli of the normal training trials (i.e. Pair B v C and C v D). They were as follows:

Modification 1. In this condition (Condition 1) the version of the stimulus retained the volume of the parent stimuli, but the respective height of the stimuli within each pair were interchanged. One constraint of the modified versions was that they would be as wide as they were deep (i.e. their horizontal cross-section would be square). Figure 10 (2) records the relative sizes and shapes of these stimuli, and Table 13 (2), their actual dimensions. The surface and colour of the modified versions was the same as for their parent stimuli.

Modification 2. In this condition (Condition 2) the volume of the modified stimuli was identical to that of Stimulus C of the basic training pool. They did, however, retain the height of their parent stimulus (see Table 13-2 and Figure 10-2).

Modification 3. In this condition (Condition 3) the height of all the modified stimuli was identical and equal to the height of Stimulus C, but/

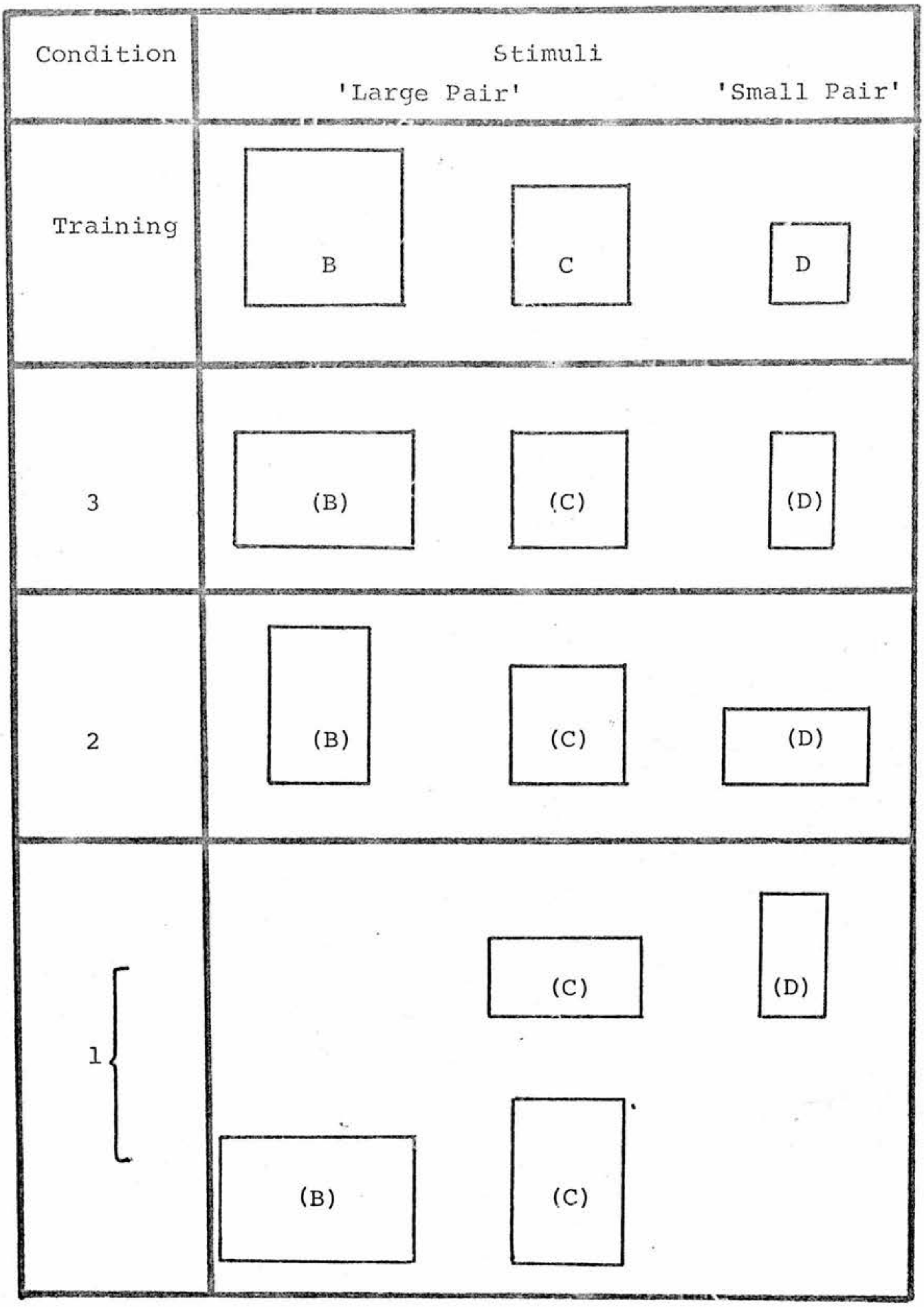


Figure 10 (2). The frontal planes (to scale) of the generalization stimuli used in the equivalence testing of Experiment 4 (2).

Note: These stimuli are as wide as they are deep.

Condition	Parent Stimuli	Equivalence Stimuli			
		Height	Width	Depth	Volume
3	D	1.50	0.82	0.82	1.00
	C	1.50	1.50	1.50	3.38
	B	1.50	2.31	2.31	8.00
2	D	1.00	1.84	1.84	3.38
	C	1.50	1.50	1.50	3.38
	B	2.00	1.30	1.30	3.38
1	D	1.50	0.82	0.82	1.00
	C	1.00	1.84	1.84	3.38
	C	2.00	1.30	1.30	3.38
	B	1.50	2.31	2.31	8.00

Table 13 (2). The dimensions of the generalization stimuli used in the equivalence testing of Experiment 4(2).

Note: The dimensions are in inches and cubic inches. It may be helpful to refer to Figure 10 (2).

but they retained the volume of their parent stimulus (see Figure 10-2 and Table 13-2).

The modification in which stimuli were constructed as wide as they were deep, constituted Stimulus Pool A. A further stimulus pool, Stimulus Pool B, was constrained in a different way in that all modifications were 1.5" deep. Otherwise, they were constructed with exactly the same rationale as Stimulus Pool A. (See Figure 11-2 and Table 14-2 for their description and dimensions).

Procedure and Design

Experiment 4 (2) was conducted over six consecutive days. The first ten trials of each day's testing consisted of non-differentially rewarded equivalence trials in which the two pairs of modified stimuli of one of the three conditions were presented on randomly alternating trials (Fellows series), five times each, to the subjects of both groups. Each subject received the conditions in a different order (a 3 x 3 Latin Square) and subjects were matched between groups in terms of order of presentation of both the conditions and the stimulus pairs. Stimulus Pool A was used for the first three days, and Stimulus Pool B for the second three days. Following each daily testing session, twenty trials were given under the same procedure as was experienced in Experiment 1 (2) - i.e. stimulus pairs B v C and C v D with appropriate differential reward.

RESULTS

Condition 1. Table 14a (2) shows the total distribution of choice made/

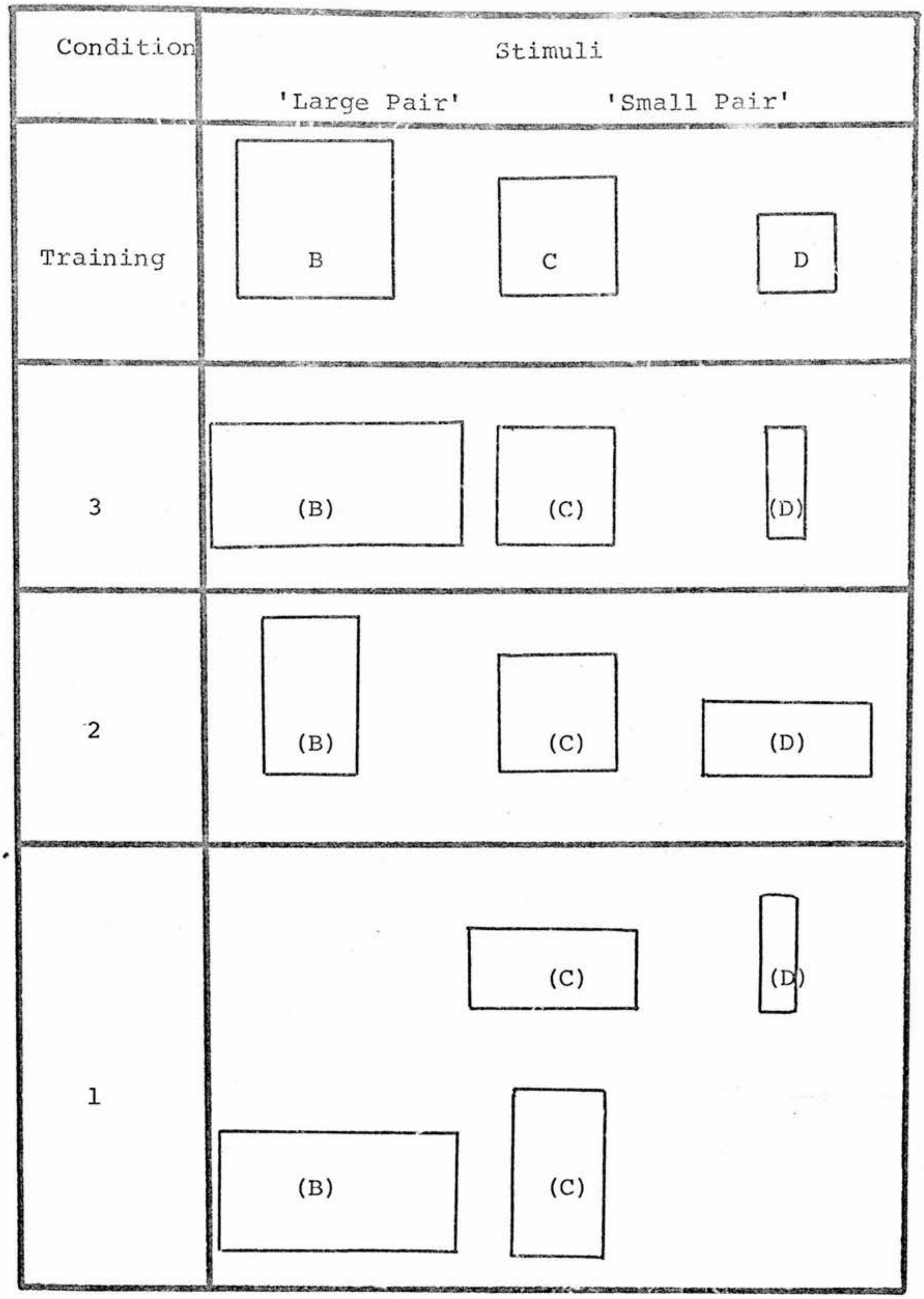


Figure 11 (2). The frontal plane (to scale) of the generalization stimuli used in the equivalence testing of Experiment 4 (2).

Note: These stimuli are all 1.5 inches deep

Condition	Parent Stimuli	Equivalence Stimuli			
		Height	Width	Depth	Volume
3	D	1.55	0.44	1.50	1.50
	C	1.50	1.50	1.50	3.38
	B	1.50	3.56	1.50	8.00
2	D	1.00	2.25	1.50	3.38
	C	1.50	1.50	1.50	3.38
	B	2.00	1.13	1.50	3.38
1	D	1.50	0.44	1.50	1.00
	C	1.00	2.25	1.50	3.38
	C	2.00	1.13	1.50	3.38
	B	1.50	3.36	1.50	8.00

Table 14 (2). The dimensions of the generalization stimuli used in the equivalence testing of Experiment 4(2).

Note: The dimensions are in inches. It may be helpful to refer to Figure 11(2).

Group	Stimulus Pool	Responses Hits	Misses
R	A	18	12
R	B	14	16
SS	A	8	22
SS	B	10	20

Condition 1.

Group	Stimulus Pool	Responses Hits	Misses
R	A	22	8
R	B	24	6
SS	A	26	4
SS	B	20	10

Condition 2.

Group	Stimulus Pool	Equivalence	Pairs		
		(B) - (C)		(C) - (D)	
R	A	15	0	14	1
R	B	14	1	13	2
SS	A	1	14	15	0
SS	B	4	11	9	6

Condition 3.

Table 14a(2). The total distribution of choices during the equivalence testing of Experiment 4(2).

Note: Where appropriate, "HIT" = consistent with 'Taller is Bigger'.

made during equivalence testing for both groups. Responses were coded as 'hits' when they were consistent with the heuristic that height is indicative of 'size', and 'misses' when they were not. Group R responded at chance during these tests with both Stimulus Pool A and B. With Stimulus Pool A, Group SS showed a reliable choice bias in the direction opposite to that which the heuristic predicts (Binomial Test - $p < 0.05$, for a two-tail test). With Stimulus Pool B, Group SS maintained this trend against the heuristic, but it just failed to reach the 5% level of significance.

Condition 2. The total distribution of responses for both groups is displayed in Table 14a (2). Responses were categorized in the same way as they were for Condition 1. Group R exhibited a significant choice bias in favour of heuristic for both of the stimulus pools (Binomial Test - $p < 0.002$ and $p < 0.05$, for two-tail tests). Group SS exhibited a significant choice bias with Stimulus Pool A in favour of the heuristic (Binomial Test - $p < 0.002$, for a two-tail test) but whilst this trend was evident with Stimulus Pool B, it just failed to reach the 5% level of significance.

Condition 3. Responses in this condition could not reasonably be classified in the same way as above, since all stimuli used in equivalence testing were of the same height. The heuristic would predict no choice bias in either of the equivalence pairs, but an examination of Table 14a (2) shows that a choice bias does exist for both pairs - and it is significant (Binomial Test - $p < 0.002$ for a two-tail test, for both pairs). This is the case for both Stimulus Pool A and B. Group R also exhibits a significant choice bias for both stimulus/

stimulus pools (Binomial Test - $p < 0.05$, $p < 0.002$ for two-tail tests). Thus, the responding of both groups is strongly against the heuristic.

DISCUSSION

Evidence for the operation of the heuristic involving the height dimension as the sole index operating in the identification of 'size' was only found in Condition 2 - a condition in which 'volume' offered no differential cues. Indeed, in Condition 3, both groups exhibited choice behaviour which strongly opposes this heuristic, as did Group SS in Condition 1, with Group R responding at chance. In the case where the heuristic 'Taller is Bigger' is supported (i.e. in Condition 2) the point has already been made that no differential volume cues are available, since stimuli were all constructed of the same volume. In the case where the heuristic is not supported (i.e. Condition 3 and Group SS in Condition 1) an alternative interpretation can be advanced - that subjects are, in fact, conserving volume since not only are these cues available, but they predict responses in the opposite direction to the heuristic involving height.

Whilst it is felt that this is an important area of investigation (particularly in relation to what is known about conservation in children), the results reported in the current experiment will not be followed up (as they might be) since the prime concern of the investigation is to learn more about the many relationships which it is predicted are involved in discrimination learning.

EXPERIMENT 5 (2)

INTRODUCTION

The results of the experiments, thus far, strongly support the view that Group R have acquired a rule of relation in their commerce with the choice situation, whereas Group SS have learned to respond to a specific stimulus size. (The previous experiment represented a limited attempt to determine what parameters might be used in the representation of 'size' - and a more thorough investigation is to be carried out elsewhere). The results of Experiment 3 (2) indicate that whatever is learned can be applied by both groups over a number of different situations other than the training situation. However, the novel situation of Experiment 3 (2) resembles, very much, those of the training trials - for example, choice was still between two alternatives which were simultaneously presented, even though the stimuli present may, indeed, be novel, themselves.

The question arises with respect to Group R, as to whether the rule acquired can be applied to novel situations which resemble the training situation to a much lesser degree than do conventional transposition-type equivalence tests. In the case of the experiments in question, can Group R apply their rule ('larger') to a situation in which the total training stimulus pool is simultaneously present ('largest'), or is it merely confined to the two-stimulus presentation situation? And with respect to Group SS, who have already shown their considerable vulnerability to interference in test situations merely involving/

involving the selection of one stimulus from a pair, can their performance be maintained when the number of choices simultaneously available is increased in the same way as for Group R?

Experiment 5 (2) is designed to answer these questions by exposing the subjects of both groups to such situations, whilst ensuring that the original discrimination is not lost.

METHOD

Subjects

All subjects of Group SS (n=6) and the reduced Group R (n=3) took part in this experiment.

Apparatus

The same W.G.T.A. and stimulus tray were used as were used in the previous experiments of this chapter. However, an extra stimulus tray was used on some trials. This tray was identical in every respect to the original tray, save that it had an extra foodwell. The foodwells of this tray were located 2½" from the leading edge of the tray (as before) with the centre foodwell 5½" from the outside edges. The other two foodwells were placed 3" from the centre one, on either side.

Stimuli

Three stimuli were used in this experiment - the normal white versions of Stimulus B, C and D.

Procedure and Design

During/

During the first twelve trials of each day's testing, subjects were presented not with stimulus-pairs, but with stimulus-triads on the 3-stimulus tray. The triad consisted of Stimulus B, C and D, which was presented in a predetermined sequence of the six possible configurations. The predetermined sequence was arranged such that the six configurations occurred twice every twelve trials and that the location of the rewarded stimulus was never in one location for more than two consecutive trials. During these twelve trials, Group SS had responses to Stimulus C rewarded, and not to Stimulus B or D (i.e. their reward contingency remained unchanged, but the choices available on any trial was increased); whilst Group R has responses rewarded to Stimulus B and not to Stimulus C or D (i.e. their reward contingency remained unchanged in terms of the rule 'larger'). A correction procedure was operated in the same way as in Experiment 1 (2) and the retraining procedures in all subsequent experiments, and the general testing procedure remained unchanged.

Following the first twelve trials of each day's testing, the three-stimulus tray was replaced with the two-stimulus tray and twenty-four trials were administered according to the procedure of Experiment 1 (2) with the stimulus pairs, to determine whether the first twelve trials of the day had produced any disruptive effects. Training was carried out until a criterion of eighteen correct responses out of twenty consecutive trials was reached in those trials on which triads were presented. A further criterion was established of zero errors in two consecutive days of testing.

RESULTS

Subjects/

Subjects of Group R immediately reached criterion on the B v C v D triad, without error. Their performance on the retraining trials was, equally, unaffected. Table 15 (2) records the performance of Group SS up to the 18/20 criterion and Table 16 (2) shows the performance up to the more stringent criterion, both in terms of trials and errors. Clearly, the performance is considerably worse than that of Group R, and a statistical test would be superfluous. Further, significantly more errors were made to Stimulus B than to Stimulus D, during this training (t-test for related measures - $t = 7.05$; $df = 5$; $p < 0.001$ for a two-tail test).

DISCUSSION

The performance of the two groups in the novel situation introduced in the current experiment, on a discrimination task far removed from the training situation used, was markedly different. Group R made perfect transition from the choosing of the 'larger' of two stimuli to choosing the 'largest' of three, demonstrating the further generality of their rule. Group SS, on the other hand, whilst they did learn the new task and even though their performance in terms of trials and errors to criterion did suggest some positive transfer, performed at a level far inferior to that of Group R on the transition.

The inability of Group SS to transfer to the novel situation with the ease of Group R lends further support to the position of Wertheimer discussed in the earlier experiments, in terms of the relative vulnerability to disruption. The initial discrimination training of Experiment 1 (2) suggested that one source of interference may simply by/

Group	Subject	Trials	Errors		
			Total	To B	To D
SS	1	24	8	7	1
	2	15	4	4	0
	3	29	8	3	5
	4	2	2	1	1
	5	15	7	7	0
	6	21	3	3	0
	Total	106	32	25	7
	Mean	18	5	4	1
R	7	0	0	0	0
	8	0	0	0	0
	9	0	0	0	0
	Total	0	0	0	0
	Mean	0	0	0	0

Table 15 (2). The performance of the subjects of the 2 groups up to the 18/20 criterion in Experiment 5 (2).

Group	Subject	Trials	Errors		
			Total	To B	To D
SS	1	82	16	12	3
	2	61	11	9	2
	3	40	11	6	5
	4	31	5	4	1
	5	76	13	11	2
	6	58	5	3	2
	Total	348	61	45	15
	Mean	58	10	7	3
R	7	10	3	3	0
	8	2	1	0	1
	9	4	2	1	1
	Total	16	6	4	2
	Mean	5	2	1	1

Table 16 (2). The performance of the subjects of the 2 groups up to the more stringent criterion of Experiment 5(2).

by the passage of time (i.e. from trial to trial), whilst the results of Experiment 2 (2) indicated that the presence of novel stimuli immediately adjacent to the choice trial could affect that choice suggested another source of interference. In the current experiment the vulnerability of the ability to conserve the identity of a specific stimulus value is radically changed when the conditions of presentation are changed in terms of the number of stimuli present - even though the stimuli, themselves, are in no way novel. The stability and general applicability of whatever it is that Group SS have has learned, is thus far inferior to the learning of Group R.

Despite the initial asymmetry of the two groups, however, the terminal performance of Group SS did meet the stringent criterion of the current experiment, which is required by Experiment 6 (2) in testing the generality of what has been learned, further.

E X P E R I M E N T 6 (2)

INTRODUCTION

The terminal performance of both groups in the previous experiment indicates that, whilst still preserving the initial discrimination trained in Experiment 1 (2), Group SS could reliably choose Stimulus C and Group R choose Stimulus B from the Triad BCD. The current experiment is designed to test the applicability of the learning from the trials in which the triad was presented to similar novel situations in which new triads are used - i.e. with triads equivalent to one-step transposition testing of Triad BCD.

Thus, Group R are given the opportunity to apply the rule 'largest' to new triads, and Group SS have their ability to conserve a specific stimulus value, further tested. Indeed, it may well be the case that in the transition from discriminations involving pairs to those involving triads, Group SS have acquired a rule 'middle' rather than remaining stimulus-bound. The equivalence testing of the current experiment is designed to determine whether this has occurred. In later experiments in this series, it is planned to ask one half of Group SS to conserve a specific stimulus value (Stimulus C) from a very much enlarged stimulus pool, whereas the other half will be asked to respond on a different basis. For this reason, the half of Group SS which will carry on conserving a single stimulus from many different triads, do not take part in Experiment 6 (2).

METHOD

Subjects/

Subjects

Six subjects took part in Experiment 6 (2): the three remaining subjects of Group R and three of Group SS (Subjects one, two and three). Subject four, five and six of Group SS did not take part in this experiment.

Apparatus

The same W.G.T.A. as has been previously described was used in this experiment, along with the same three-stimulus tray as was used in the previous experiment.

Stimuli

Stimuli A, B, C, D and E were used in this experiment. The normal versions were used.

Procedure and Design

Testing was carried out for two consecutive days. The first ten trials of each day were differentially rewarded trials with triad B v C v D following the procedure of the corresponding trials of the previous experiment. Group R was rewarded for responding to Stimulus B and the representatives of Group SS for responding to Stimulus C. If subjects made no more than one error during these ten trials, they were allowed to go on to an equivalence testing phase for a further twenty trials (per day), otherwise they were retrained to the stringent criterion of Experiment 5 (2). Fifteen of these trials were equivalence trials with non-differential reward using triads A v B v C and C v D v E presented in a randomly alternating series (Fellows), and there were also/

also five randomly interpolated differentially rewarded trials using Stimulus triad B v C v D to check whether the discrimination was being interferred with. If more than one error occurred during these five trials (per day) that day's testing was discarded, and the subject retrained to criterion as detailed above. As in all triad presentations, the location of the reward was randomly varied and the six possible configurations were equally represented. A total of thirty equivalence trials were given over the two days' testing - the equivalence tests being analogous to the classical one-step transposition trials common in discrimination experiments.

As in all training and testing, stimuli were frequently washed and repainted, and drawn from a large stimulus pool from trial to trial.

RESULTS

No subject required retraining since their performance during the first ten trials of the day and the interpolated training trials was good (Subject eight and nine made one error each over the two days, and Subject three made two).

Table 17 (2) displays the distribution of the equivalence testing responses across the stimuli of the two triads, for both groups. Visual inspection indicates that all the subjects of Group SS that took part in the experiment chose Stimuli C much more than the other stimuli; and the subjects of Group R, equally, chose the largest of each triad. All subjects on each triad showed a significant deviation from chance responding during the equivalence testing - the 'flattest' distribution/

Group	Subject	Stimulus Triad					
		A	B	C	C	D	E
SS::	1	0	0	15	15	0	0
	2	0	1	14	14	1	0
	3	0	0	15	10	4	1
	Total	0	1	44	39	5	1
	Mean	0	0	15	13	2	0
R	7	13	2	0	14	1	0
	8	13	2	0	13	1	1
	9	12	3	0	15	0	0
	Total	38	7	0	42	2	1
	Mean	13	2	0	14	1	0

<u>Table 17 (2)</u>. <u>The distribution of responses during equivalence testing with triads AvBvC and CvDvE of Experiment 6 (2)</u>.

Note: The means are rounded off to the nearest integer distribution of responses was that of Subject three of Group SS on triad C v D v E, which was still a significant deviation from chance responding (Chi-square 1-sample test - Chi-square = 8.4; df = 2; $p < 0.02$).

DISCUSSION

Group R, again demonstrated the generality of their rule 'largest' in dealing with two novel stimulus triads. The performance of those subjects of Group SS who took part in the current experiment indicates that in reaching criterion during Experiment 5 (2), they were responding to a specific stimulus value, and did not acquire an 'intermediate' rule. This is consistent with results of Group SS from the other experiments, thus far.

It appears that Group R has acquired a rule of relation in the 'classical' sense, whilst Group SS are, in the 'classical' sense, absolute responders.

EXPERIMENT 7 (2)

INTRODUCTION

The results of the previous experiment have shown that whilst Group R and Group SS are successfully responding to Stimulus B and Stimulus C, respectively, of Triad BCD, they can reliably respond to embedded equivalence testing triads. The current experiment is designed to determine whether such responding on the two equivalence triads can be maintained when the whole of each day's testing consists, solely, of these two triads presented in a randomly alternating manner in the same way as with the training pairs of Experiment 1 (2), with appropriate differential reward. Thus, Group R will be asked to transfer their rule 'largest' to the two stimulus triads that they experienced in the equivalence testing of the previous experiment, but without the benefit of the interpolated training trials using the relatively familiar Triad BCD. In a similar way, those subjects of Group SS that took part in the previous experiment will be asked to conserve their specific stimulus value.

That half of Group SS which did not take part in the previous experiment and which has never experienced the equivalence triads used therein, is asked to learn the identity of more than one specific stimulus. As an alternative to this, however, they are given an opportunity to acquire a rule, instead - i.e. 'intermediate'. Group SS, in Experiment 1 (2) appear not to have acquired an 'intermediate' rule in learning the discrimination, and the evidence of the previous experiment/

experiment does not suggest that the rule 'intermediate' has been used to reach criterion on the Triad BCD. However, in the current experiment, for the newly created group, the conditions should be much more favourable for this type of learning, since an extra load is put upon the process of learning specific stimulus values, as there are two of them (i.e. one in Triad ABC and one in Triad CDE, see 'Procedure').

The purpose of the current experiment is not, therefore, to compare the acquisition performance of the three groups, as such, but to examine further the performance of the groups that took part in the previous experiment, and to produce a new group with modified reward contingencies.

METHOD

Subjects

All nine subjects from the previous experiments took part in Experiment 7 (2).

Apparatus

This was the same as in the previous experiment.

Stimuli

The stimulus pool was identical to that of the previous experiment.

Procedure and Design

An/

An additional group was created for this experiment (and subsequent experiments), producing three groups. Group R (n=3) retained its identity and the reward contingency remained unchanged. Group SS (n=3) was divided into two groups: Subject one, two and three made up the new Group SS (n=3) which had its reward contingency retained as before; Subjects four, five and six made up Group SSI (n=3) and their reward contingency was modified in that they were rewarded for responding to Stimulus B of triad A v B v C and D of C v D v E. Figure 12 (2) displays the structure and reward contingencies of the three groups.

Training was carried out adopting the procedure of the corresponding trials of Experiment 5 (2) and 6 (2) up to a criterion of acquisition of eighteen correct responses our of twenty consecutive trials and then to a, further, more strict criterion of not more than one error over two consecutive days. Twenty four trials were given per day.

RESULTS

Table 18 (2) and Table 19 (2) records the performance of the three groups up to the first and second criterion, respectively, in terms of trials and errors.

DISCUSSION

Group R, clearly, has acquired the new discrimination with relative ease, and in doing so they directly reflect their performance during the equivalence testing of the previous experiment. The performance of Group SS, however, whilst reflecting the performance of the previous/

Group	N	Training Stimulus Triad: Triad 1	Training Stimulus Triad: Triad 2
SSI	3	A B C − + −	C D E − + −
SS	3	A B C − − +	C D E + − −
R	3	A B C + − −	C D E + − −

Figure 12 (2). The response contingencies and the stimulus triads used in Experiment 7 (2).

Group	Subject	Trials	Errors		
			To ABC	ToCDE	Total
SSI	1	248	67	33	100
	2	145	50	27	77
	3	151	43	24	67
	Mean	181	53	28	82
SS	4	38	10	6	16
	5	4	1	1	2
	6	14	4	1	5
	Mean	19	5	3	8
R	7	7	1	2	3
	8	6	1	1	2
	9	8	2	0	2
	Mean	7	2	1	2

Table 18 (2). The performance of the 3 groups of Experiment 7 (2), up to the 18/20 criterion.

Note: The means are rounded off to the nearest integer.

Group	Subject	Trials	Errors		
			To ABC	To CDE	Total
SSI	1	306	77	40	117
	2	260	83	42	125
	3	191	52	28	80
	Mean	252	71	37	108
SS	4	46	10	8	18
	5	4	1	1	2
	6	18	6	2	8
	Mean	22	6	4	10
R	7	14	3	1	4
	8	18	2	1	3
	9	12	2	0	2
	Mean	15	2	1	3

Table 19 (2). The performance of the 3 groups of Experiment 7 (2) up to the more stringent criterion.

Note: The means are rounded off to the nearest integer.

previous experiment in the same way as Group R, is more variable. This is interpreted as supporting the already well-established point that the retention of specific stimulus values is relatively unstable, whereas the retention of relations is not.

The performance of Group SSI suggests that there has been little positive transfer to the new discrimination problem of the current experiment from previous problems. Indeed, the contrary appears to be the case, since during the first day's testing, a significant proportion of the errors made by Group SSI were perseveration errors. However, with the exception of Subject one, Group SSI did not exhibit significant perseveration after the first day of testing (with Subject one, it was the second day). This further supports the view that the retention of the specific stimulus value is of a labile nature - a feature of Group SS (n=6) throughout the experiments, thus far.

The fact that there was stimulus perseveration (to Stimulus C) in the learning of Group SSI in the current experiment does support the view that Group SS have been, indeed, specific stimulus learners. Although it says nothing about the manner in which they (i.e. Group SSI) have acquired the current discrimination.

EXPERIMENT 8 (2)

INTRODUCTION

Experiment 7 (2) was terminated when each of the three groups reached the second (more stringent) criterion on each of their different discrimination problems. The results of the previous experiments strongly support the view that Group SS is, indeed, conserving a specific stimulus value, whereas Group R are emancipated from specific stimulus control. In the case of Group SSI, however, what has been acquired in Experiment 7 (2) is ambiguous - they may have acquired the discrimination either by retaining two specific stimulus values or by learning a rule of relation (i.e. 'middle') and become emancipated from specific stimulus values as Group R appear to have become.

The current experiment is designed primarily to test these two possibilities. Group SS did not take part in Experiment 8 (2) since their now appears to be little ambiguity in the basis of their discrimination behaviour (in these dichotomous terms). Group R were included to act as a control for the general procedure.

METHOD

Subjects

Six subjects took part in this experiment: Group R (n=3) and Group SSI (n=3). Group SS did not take part.

Apparatus

The/

The same W.G.T.A. and matt red stimulus tray as was used in the previous experiment was used in Experiment 8 (2).

Stimuli

As in Experiment 7 (2), stimulus triads A v B v C and C v D v E were used. Normal, white versions of the stimuli were used.

Procedure and Design

Testing was carried out for two consecutive days. The first twelve trials of each day consisted of differentially rewarded trials with the stimulus triads A v B v C and C v D v E, following the procedure of the previous experiment. Subjects were allowed to make no more than one error during these trials before they proceeded to a further series of twenty-three trials in which there were twelve non-differentially rewarded equivalence trials administered with eleven interpolated training trials following the procedure of the first twelve trials of the day. If more than one error was made during the first twelve trials of the day, or the eleven interpolated training trials, the equivalence testing performance of that day was discarded and the subjects required to reach the criteria of Experiment 7 (2), again.

The stimuli of the equivalence tests consisted of triads A v B v D and B v D v E, and during the twelve equivalence trials of one day's testing were presented in a randomly alternating fashion with the attention to configuration and reward location previously mentioned. Thus, twenty-four equivalence trials were given during the current experiment.

RESULTS/

RESULTS

Table 20 (2) records the distribution of choices during equivalence testing for the two groups. Group R reliably chose Stimulus A from the larger triad, and B from the smaller (statistical tests were not applied to the data since there is no possible ambiguity in the data for this group). Group SSI reliably chose Stimulus B of the larger triad and D of the smaller (Chi-square test - Chi-square = 33.6; df = 2; $p < 0.001$ for A v B v D and Chi-square = 20; df = 2; $p < 0.001$ for B v D v E: as measure of deviation from chance responding within a triad).

DISCUSSION

The performance of Group R continued in the same way as before - they applied their rule 'largest' over a large number of different testing situations (in terms of conventional paradigms). The performance of Group SSI, suggests that they, too, have become emancipated from the control of specific stimulus values and acquired an 'intermediate' rule, since they reliably chose one of the two equally-rewarded stimuli present in each equivalence triad. However, before it is accepted that this group has acquired a rule, much more extensive testing over a wider range of stimulus groups needs to be carried out. Such testing is postponed until Experiment 11 (2).

Group	Subject	Stimulus Triad					
		A	B	D	B	D	E
SSI	1	1	9	2	4	8	0
	2	0	10	2	4	8	0
	3	1	9	2	4	7	1
	Total	2	28	6	12	23	1
	Mean	1	9	2	4	8	0
R	7	11	1	0	12	0	0
	8	12	0	0	12	0	0
	9	12	0	0	11	1	0
	Total	35	1	0	35	1	0
	Mean	12	0	0	12	0	0

Table 2 0(2). The distribution of responses on the equivalence testing of Experiment 8 (2) for Group SSI and Group R.

Note: The means are rounded off to the nearest integer.

E X P E R I M E N T 9 (2)

INTRODUCTION

The opportunity is taken in the current experiment to examine whether whatever is learned about three-dimensional stimuli in normal training triads is generalized to two-dimensional representations of these familiar stimuli. Representations of three-dimensional objects in a planometric manner can be done in several different ways. Stevenson and McBee (1958), for example, have compared the ease of learning in children using cuboid objects with their planometric representations in the form of cardboard cut-outs (squares) and painted patterns (squares) on cardboard mounts. These investigators found superior learning in the case of the stereometric cubes, and Harlow has demonstrated an analogous finding with monkeys (Harlow, 1945). Other investigators, for example, Hochberg and Brooks (1962), have used outline perspective drawings.

In the current experiment, the decision was taken to use painted representations of a single face of the cuboid stimuli - the same colour and surface texture as the parent stimuli - rather than any of the other possibilities. The reason follows from the results of Experiment 4 (2) in which the role of the dimension 'height' and 'volume' was examined. No secure generalizations could be made on the basis of the results obtained, and the current experiment represents a further attempt to determine the sufficient conditions for the discrimination behaviour of the subjects to be retained. In the current/

current experiment, the generalization stimuli are to represent a single face of the cuboid, parent stimulus. The problem of which face to use (i.e. the frontal or the top face) was circumvented by using both - being presented in the vertical and horizontal plane, respectively, on separate trials.

METHOD

Subjects

Six subjects took part in this experiment. Group R (n=3) and Group SSI (n=3). Group SS did not take part.

Apparatus

The same W.G.T.A. was used as had been used in previous experiments, with the matt red stimulus tray.

Stimuli

Five sets of stimuli were used in this experiment. The basic stimulus pool was used, and four modifications of each stimulus of this pool was constructed.

Modification 1. The normal white stimulus cubes were mounted at the centre of a piece of wood 1/10" x 3" x 3", which was painted the same matt red as the stimulus tray - this was Modification 1a. A version was made corresponding to each of the five stimuli of the basic stimulus pool. A further modification was carried out (Modification 1b) in which the stimulus cubes were mounted on wooden plaques identical/

identical to those of Modification 1a, but not in the centre: one edge of the cube was positioned coincident with one edge of the stimulus plaque and at its centre. These two modifications and the way in which they were deployed can be seen in Figure 13 (2). The former modification comprise the stimuli of Condition FS (= Flat/Stereometric) and the latter of Condition US (= Upright/Stereometric). Care was taken to ensure that the surface texture of the plaques and the edges of the plaques matched that of the stimulus tray.

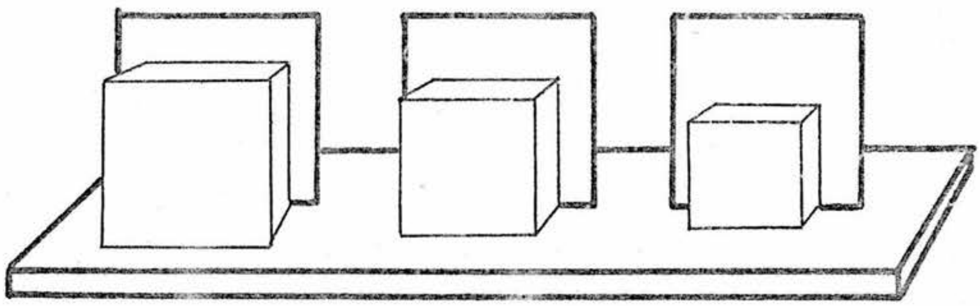
Modification 2. Stimuli were mounted on plaques in an identical manner to the above, except for the fact that planometric versions were used in place of the stereometric ones. Modification 2a had a square of matt white painted in the centre of the plaque, the same texture as the stereometric stimuli, and Modification 2b had a similar square positioned with its edge coincident with that of the plaque, itself. As before, the two modifications and the way in which they were deployed can be seen in Figure 13 (2). The former modification was used for the stimuli of Condition FP (=Flat/Planometric), and the latter of Condition UP (=Upright/Planometric).

For each of the cuboid stimuli of the basic stimulus pool, four modified versions were made along the lines outlined above, using squares equal to the cross-section of the parent (cube) stimulus. Thus, each of the stimuli of the basic stimulus pool was represented in each of the four conditions.

Procedure and Design

Testing was carried out on four consecutive days. Each day's testing consisted/

Condition US (= Upright-Stereometric).



Condition UP (= Upright-Planometric).

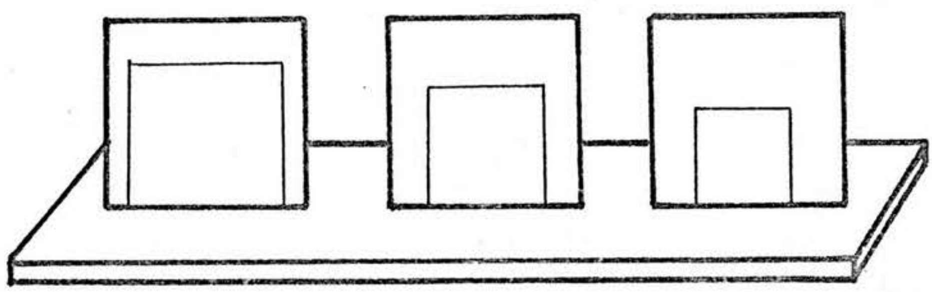


Figure 13 (2). The deployment of the equivalence testing stimuli of Experiment 9(2).

Note: In Condition FP and FS, the stimulus plaques above are rotated away from the reader by 90° and the stimuli placed centrally, thereon.

consisted of twelve differentially rewarded trials with triads A v B v C and C v D v E, following the general procedure of Experiment 7 (2). No more than one error during these trials allowed the subjects to begin a series of twenty-three further trials consisting of twelve non-differentially rewarded equivalence trials and eleven randomly interpolated differentially rewarded training trials, as in the first twelve trials of the day. If more than one error was made during the training trials of the day's testing, the day's results were discarded and the subject required to re-meet the criteria of Experiment 7 (2).

On day one and three of testing, Conditions US and UP were run (i.e. the Upright condition) and on day two and four, Conditions FS and FP (i.e. the Flat condition). On any one day of testing, the twelve equivalence trials were made up of six stereometric stimuli and six planometric stimuli - each representing three of the six possible configurations of the parent triads. The remaining configuration were presented during the second day of testing for those conditions. Thus over four days of testing, every configuration of each of the two parent triads (A v B v C and C v D v E) was represented once in each of the four conditions.

RESULTS

Table 21 (2) displays the distribution of the subjects choices on the various types of equivalence tests for Group R and Group SSI. Overall performance of all the subjects on Condition S can be seen to be reliably good in terms of positive transfer from the training trials - as every subject showed a deviation from chance responding, in the direction/

Group	S	Condition			
		Stereometric		Planometric	
		Upright	Flat	Upright	Flat
SSI	1	10	12	2	3
	2	9	10	2	3
	3	8	11	3	2
	Total	27	33	7	8
R	7	11	9	3	3
	8	11	10	3	5
	9	12	11	2	5
	Total	34	30	3	13

Table 21 (2). The number of 'correct' responses made by Group SSI and R under the equivalence conditions of Experiment 9 (2).

Note: The scores for the 'small' and 'large' triads have been combined. The maximum score in any cell is 12.

direction of positive transfer (Binomial Test - $p<0.01$ for a two-tail test for the worst subject), whilst the performance on Condition P is poor, with no subjects exhibiting a deviation from chance responding in the direction of positive transfer.

A more extensive analysis of the data of this experiment was carried out by applying a three-Factor Mixed Design Analysis of Variance with repeated measures on two of the factors (Winer 1962, pages 319-337). Significant differences were found between Condition S and P ($F = 496$; $df = 1,4$; $p< 0.001$. See Table 22 (2) for Source Table), and Condition U and F ($F = 15.51$; $df = 1,4$; $p<0.025$. See Table 22 (2) for Source Table), and the interaction between Stereo/Plano and Upright/Flat factors was also significant ($F = 67.00$;$df = 1,4$; $p<0.001$. See Table 22-2). The three-way interaction involving the groups and these two factors was also significant ($F = 455$; $df = 1,4$; $p< 0.001$. See Table 22-2). Other effects were not significant. Further statistical interpretation of the significant F-values was not carried out since the design of the experiment and the nature of the results enable interpretation to be carried out direct from Table 21 (2). In Condition S, three of the six subjects make less errors under Condition U than F, whilst in Condition P less errors are made by four subjects under Condition F than U and only one subject going against this trend - this interprets the two-way interaction. The three-way interaction goes further by identifying the subjects contributing to the two-way interaction as having <u>group</u> identity: all subjects of Group SSI made less errors under Condition US than FS, whereas for Group R, the reverse was the case. The performance of the two groups was essentially the same/

Source	SS	*DF*	MS	*F*	*p*
Total	351.35	23	-	-	-
Bet.Subs	7.83	5	-	-	-
Groups	4.17	1	4.17	4.53	0.1
Error	3.67	4	0.92	-	-
With.Subs	343.50	18	-	-	-
Dimension	322.67	1	322.67	496.00	0.001
Plane	9.00	1	9.00	15.51	0.025
GxD	0.23	1	0.23	0.40	0.1
GxP	1.50	1	1.50	2.58	0.1
DxP	0.67	1	0.67	67.00	0.001
GxDxP	4.55	1	4.55	455.00	0.001
Error-1	2.60	4	0.65	-	-
Error-2	2.33	4	0.58	-	-
Error-3	0.07	4	0.01	-	-

Table 22 (2). Source Table of the variance contributed by the Factors of Experiment 9 (2) using a 3-Factor Mixed Design with Repeated Measures on 2 Factors.

Note: Dimension = The stereo/planometric factor; Plane = the plane of orientation or so-called upright/flat factor. The deployment of the error terms is outlined with Table 15 (4).

same for Condition P.

DISCUSSION

The performance of both groups on the planometric stimuli was poor. Indeed, both groups performed at around chance levels. The fact that performance was good on the stereometric stimuli (i.e. those with the plaque) strongly suggest that it was not the procedure, itself, which was disruptive. The superiority of Condition F over Condition U was significant, and it is tempting to suggest that in acquiring the original discrimination and subsequent ones, the top plane of the cuboid is more important than the frontal plane. However, there are reasons which suggest that this interpretation may be in error. The perception of the planometric stimuli in the upright condition ought to be more difficult than in the flat condition, since in the latter's case, the white square of the stimulus is prominent upon the matt red surface of the stimulus tray and the matt red plaque becomes very much part of the tray's surface (i.e. it is the same colour, brightness and of the same surface texture, and is very thin). Thus, the most significant contour in the case of the flat condition is the stimulus/ plaque border and not the plaque/tray border. In the case of the upright condition, however, the stimulus/plaque border is rivalled in prominence by the border between the plaque and the organized and highly patterned backdrop consisting of the wall and floor of the stimulus arena, the limited-vision screen and part of the stimulus tray, itself. These form a stable background which, with motion parallax, moves in register against the plaque and must reduce the possibility of the planometric stimuli gaining the prominence it would in the flat condition./

condition.

It is not surprising that a significant superiority was demonstrated for Condition F over Condition U for planometric stimuli but not for stereometric stimuli (the two-way interaction), since the performance was so good on the stereometric stimuli that any difference between the planes would be obliterated by the ceiling effect, whereas in the case of the planometric stimuli, which were operating at around chance, the basement effect would not interfere (it only could if there were strong negative transfer).

It is noteworthy that the overall performance of the two groups is similar in generalization testing (i.e. the 'groups' effect did not reach significance). The procedures involved require the subjects to deal with highly novel testing situations (i.e. the plaques and planometric stimuli) which could be predicted as having a detrimental effect upon the retention of specific stimulus values, but little effect upon the perception of relations. The results of the current experiment, therefore, suggest that Group SSI have learned their current discrimination in a way similar to Group R - that they have acquired a rule of relation. Thus, these results are consistent with those of the previous experiment.

EXPERIMENT 10 (2)

INTRODUCTION

The previous experiment has demonstrated the superiority of stereometric over planometric stimuli and the superiority of the horizontal plane over the vertical plane of presentation. Although transfer to the planometric condition was very weak (if present at all) this may be the result of insufficient exposure to the stimuli of this condition. Warren and McGonigle (1968) have shown that in equivalence tests (i.e. with non-differential reward) transfer is often not detected when, with subsequent testing with differential reward, it is. This becomes important on two counts. It may be that the very small asymmetry between the two planes of presentation is the product of an insensitive investigative procedure, either in terms of reduced familiarity with the generalization stimuli, or in terms of the relatively small amount of data such tests produce.

Experiment 10 (2) is designed to give subjects much more experience of the planometric stimuli, in conjunction with appropriate reward, in the expectation previous experiment (outlined above) might be cicumvented. Further, such a procedure would prove a far more critical test of the symmetry of the behaviour of the two groups, which, in the terms of the current series of experiments, is of prime importance.

METHOD

Subjects

Group/

Group R (n=3) and Group SSI (n=3) took part in Experiment 10 (2).

Apparatus

The same W.G.T.A. and matt red three-stimulus tray as was used in the previous experiment was used in the current one.

Stimuli

The stimuli used were the same as those of the previous experiment, except for the fact that the stereometric, plaque-mounted stimuli were omitted. That is, the basic stimulus pool was used as well as the two planometric versions of this pool - in both the vertical and the horizontal plane.

Procedure and Design

Each day's testing was divided into blocks of six trials. The first six trials of each day were made up of normal, differentially rewarded training trials with the stimuli triads and general procedure of Experiment 7 (2). The second six trials of each day consisted of six differentially rewarded trials with the planometric versions of the training stimuli. Thereafter, blocks of trials consisting either of normal stereometric stimuli or their planometric counterparts were alternated throughout the day's experimental session. A total of forty-eight trials were given per day - twenty-four normal training trials and twenty-four transfer trials. In each trial block, three of the six possible configurations of each triad were represented once, and attention was given to configurations and reward locations as outlined in earlier experiments in the current chapter. Over a complete day's testing/

testing, each of the two triads was presented a total of twelve times, as was their planometric versions.

Testing was carried out for a total of eight days. On odd-numbered days the planometric versions were used in the transfer trials, presented in the horizontal plane, whilst on even-numbered days they were presented in the vertical plane (Condition F and U, respectively). Thus, a total of ninety-six trials was given under each of the two planometric conditions. As in previous experiments involving transfer and equivalence tests, a check on the retention of the training discrimination was used each day. Any subject making more than one error in a day's training trials was required to re-meet the appropriate criteria before proceeding with the experiment, and that day's data was discarded.

RESULTS

No subject required such retraining in this experiment. Table 23 (2) shows the performance of the two groups on the transfer trials of the two conditions of test. Visual inspection suggests that more positive transfer was made to Condition F than to Condition U, and this difference reaches significance (Wilcoxon Matched-Pairs Signed-Ranks Test - $T = 1$; $n = 6$; $p = 0.05$ for a two-tail test). An analysis of the variance of Table 23 (2) using a two-Factor Mixed Design with Repeated Measures on one-Factor shows that more positive transfer was made by Group R than Group SSI to the transfer stimuli, as a whole ($F = 8$; $df = 1,4$; $p < 0.05$. See Table 24 (2) for Source Table). The interaction between the groups and the Upright/Flat Factor was not significant ($F = 0.84$; $df = 1,4$; $p < 0.4$. See Table 24 (2) for Source Table)./

Group	Subject	Transfer Condition F	Transfer Condition U
SSI	1	52	35
	2	40	37
	3	52	45
	Total	142	117
	Mean	47	39
R	7	62	40
	8	87	45
	9	68	69
	Total	217	154
	Mean	72	50

Table 23 (2). The total number of positive transfer responses by the subjects of both groups on each of the 2 transfer conditions of Experiment 10 (2).

Note: The responses to the 2 stimulus triads have been combined.

Source	SS	DF	MS	F	p
Total	2764.67	11	-	-	-
Bet.Subs	1466.67	5	-	-	-
Groups	1008.33	1	1008.33	8.80	0.05
Error	458.33	4	114.58	-	-
With.Subs	1298.00	6	-	-	-
Conditions	675.00	1	675.00	5.26	0.10
Gps x Cond	108.00	1	108.00	0.04	0.20
Error	515.00	4	128.75	-	-

Table 24 (2). Source Table of the variance contributed by the Factors of Experiment 10 (2).

Table).

DISCUSSION

The results of the current experiment show that even with extensive training, the superiority of the horizontal plane over the vertical plane is only slight. Nevertheless, the results are on the borderline of significance in favour of the horizontal plane. However, in light of the problems of equating performance using the two planes, any conclusions suggesting that the horizontal plane of the cuboid stimuli is more important in discrimination than the vertical, must be tentative.

What is noteworthy, is that under these more exacting conditions of test, the symmetry of the two groups displayed in the previous experiment breaks down - the performance of Group SSI being significantly worse than that of Group R. Whilst the differences are by no means large, it does suggest that whatever Group SSI have acquired in discriminating ought to be examined further, since the results of the current experiment are at variance with those of Experiment 8 (2) and 9 (2) in terms of the possible basis of the discrimination. Indeed, if the results of the current experiment are to be favoured over the results of the previous one (and the fact that a more extensive testing procedure was employed suggest that this is the more reasonable), then the indication is that Group SSI may have acquired their most recent discrimination on a basis similar to Group SS rather than Group R.

The next experiment is designed to answer this question.

E X P E R I M E N T   11 (2)

INTRODUCTION

Over the relatively extensive testing of the previous experiments (at least by the standards of conventional approaches) stability of the rule 'largest' that Group R appear to have acquired is high. The performance of Group SS, however has been much inferior, in this respect - although in conserving a specific stimulus value, they have reached the same exacting levels of performance as have Group R. Nevertheless, it does appear to be the case that learning is eminently possible in both the 'relative' and the 'absolute' sense of the 'classical' dichotomy. The range of tests over which Group R has applied its learning indicate that it is, indeed, a rule of relation emancipated from specific stimulus control.

The current experiment serves to, further, extend the range of tests over which Group R is asked to apply its rule. The range is extended both in the size of the stimulus pool from which triads are drawn, and the number of different triads that are used. In the case of Group SS, their ability to conserve a single stimulus value is tested under the same extended conditions as for Group R.

The further purpose of Experiment 11 (2) is to determine the basis for the discrimination that Group SSI acquired in Experiment 7 (2). The results of Experiment 8 (2) suggest that Group SSI have acquired a rule of relation, i.e. 'middle'. The results of Experiment 9 (2) support this conclusion, but a more exacting procedure based on Experiment/

Experiment 9 (2) produces contrary results. In view of the inconclusive findings, the current experiment gives Group SSI the opportunity to apply what they have learned over a wide range of novel triads. Should they have developed a rule of relation analogous to that of Group R, then their performance on the stimulus triads should mirror that of Group R. On the other hand, if they have learned to conserve two stimulus values, then their performance should be commensurably poor whenever the rewarded stimulus is not the specific stimulus that was previously rewarded. If it is the case that Group SSI are specific stimulus learners, then the results of the generalization testing of Experiment 8 (2) are somewhat of an anomaly.

METHOD

Subjects

Group R (n=3), Group SSI (n=3) and Group SS (n=3) took part in Experiment 11 (2).

Apparatus

The same W.G.T.A. and stimulus tray as was used in the previous experiment was used in the current one.

Stimuli

For the current experiment, the stimulus pool was enlarged. Originally five stimuli comprised the basic stimulus pool - Stimulus A, B, C, and D, each one having linear dimensions ½" more or less than adjacent stimuli in the series. Four additional stimuli were prepared, increasing the basic stimulus pool to nine - Stimulus A', B', C', and D',/

D', each having linear dimensions of $\frac{1}{4}$" more or less than adjacent stimuli of the new series.

Thus, Stimulus A' has linear dimensions of $\frac{1}{4}$" less than Stimulus A. Stimulus B', $\frac{1}{4}$" less than Stimulus B, etc. The new stimuli were prepared in exactly the same way as the original stimulus pool - thus, they only differed in size, and the fact that they were novel. Many identical exemplars of each stimulus were prepared and they were frequently washed and repainted, a procedure carried out in all experiments reported here.

Procedure and Design

Subjects of the three groups were given one new discrimination problem (i.e. a new stimulus triad) per day. Each day's testing consisted of a series of forty-eight differentially rewarded trials with correction procedure, using a single triad. The usual attention was paid to configuration, laterality and reward location using a number of Fellows series. Four discrimination problems were Given to Group R and Group SSI on four consecutive days using four new stimulus triads - A v A' v B, B v B' v C, C v C' v D and D v D' v E and the normal reward contingencies for these two groups were retained. Four different triads were given to Group SS, since in order to preserve their reward contingency (i.e. responses to Stimulus C, only, producing reward), Stimulus C must always be a member of the triad. The four triads used with Group SS were A v A' v C, B v B' v C, C v C' v D and C v D' v E. Partial counterbalancing of the order or presentation of the new stimulus triads was achieved within each group using three rows of a 4 x 4 Latin Square. Subjects of Group R and Group SSI were matched across/

across groups in terms of particular orders of presentation, and subjects of Group SS were matched in a similar manner in so far as triads of their series resembled particular triads of the other two groups' series.

If performance by any of the three groups was poor on this series of problem triads, then a series of <u>easier</u> problems (i.e. the individual stimuli of the triad being more discriminable, within the triad) was to be given, adopting exactly the procedure outlined above. Initially triads A' v C v D, A v B' v D and B v D' v E were to be used for Group R and Group SSI, and triads A v C v C', B v C v E and C v C' v D for Group SS. Perfect counterbalancing of order of presentation of these triads could be achieved using a 3 x 3 Latin Square. In the event of such a series of easier problems being necessary, then it was planned to re-run the more difficult problems that were initially given. The two series of discriminations were called Condition H (= hard) and Condition E (= easy), respectively.

RESULTS

Table 25 (2) records the performance of the three groups on the first series of four discrimination problems. It can be seen that both Group R and Group SS performed well on each of these problems, but the performance of Group SSI was near chance. For this reason, the three groups were given the second series of discrimination problems (Condition E) as outlined above. Their performance on these problems is also contained in Table 25 (2), as is that of the problems of Condition H which were subsequently given, a second time, i.e. Condition/

Group	S	Condition										
		H1				E			H2			
		1	2	3	4	5	6	7	8	9	10	11
SSI	1	16	17	23	16	38	48	48	30	41	44	47
	2	17	19	17	20	45	38	41	44	43	48	45
	3	20	24	17	17	42	40	44	42	45	47	47
	Mean	18	20	19	18	42	42	44	39	43	46	46
SS	4	47	38	46	39	37	34	45	47	46	46	48
	5	48	48	46	41	43	40	42	45	47	46	47
	6	45	31	36	48	41	35	46	46	48	47	47
	Mean	47	39	43	43	40	36	44	46	47	46	47
R	7	47	43	43	47	44	46	48	45	44	46	45
	8	48	47	45	43	46	48	47	46	48	48	45
	9	39	39	45	46	44	46	47	46	47	45	45
	Mean	45	43	45	46	44	46	47	46	47	45	45

Table 25 (2). Number of correct responses on each of the problems of the 2 conditions during the fixed-trial learning set of Experiment 11 (2).

Note: The table is headed by the ordinal problem no. The last 4 problems, indicated, represent a re-run of the first 4.

Condition H1 and H2, respectively. Table 26 (2) contains the means of each group represented as both raw scores and percentage correct responses, for each of the discrimination problems. This latter information is presented, graphically, in Figure 15 (2).

Visual inspection of both tables and graphs reveal that only during the first block of four discrimination problems was Group SSI considerably worse than Group SS and Group R. During the second block of three (easy) problems, Group SSI was considerably improved and this improvement was maintained over the final block of four problems of the series of eleven (i.e. the hard problems originally encountered and presented for the second time).

The performance of the three groups is compared in terms of the first block of four problems and the last block of four problems (the same problems) - since it is between these two blocks that improvement appears to have taken place. A three-Factor Mixed Design with Repeated Measures on two-Factors analysis of variance was carried out (Bruning and Kintz 1968, page 72) with Groups, Blocks and ordinal Problem Number as factors, and Table 27 (2) contains the Source Table. Group effects ($F = 128.80$; $df = 2,7$; $p < 0.001$) and Block effects ($F = 160.15$; $df = 1,6$; $p < 0.001$) were significant, as well as the Group x Block interaction ($F = 91.15$; $df = 2,6$; $p < 0.001$). An F-test for a significant interactive F showed that a significant improvement occurred from Block 1 to Block 2 (i.e. problems 1, 2, 3, 4 and 8, 9, 10, 11, respectively) for Group SSI and Group SS, but not Group R (see Table 25-2), who were presumably at their ceiling during Block 1. An alternative way of interpreting the significant interaction is to examine/

	Condition										
	H1				E			H2			
Group	1	2	3	4	5	6	7	8	9	10	11
SSI	18	20	19	18	42	42	44	39	43	46	46
SS	47	39	43	43	40	36	44	46	47	46	47
R	45	43	45	46	44	46	47	46	47	45	45

Raw Scores - Means

	Condition										
	H1				E			H2			
Group	1	2	3	4	5	6	7	8	9	10	11
SSI	38	42	40	38	88	88	92	81	90	96	96
SS	98	81	90	90	83	75	92	96	98	96	98
R	94	90	94	96	92	96	98	96	98	94	94

Percentage Correct

Table 2.6 (2). The mean performance of each group on the discrimination problems of Experiment 11 (2).

Note: The raw scores are number of correct responses out of 48 trials.

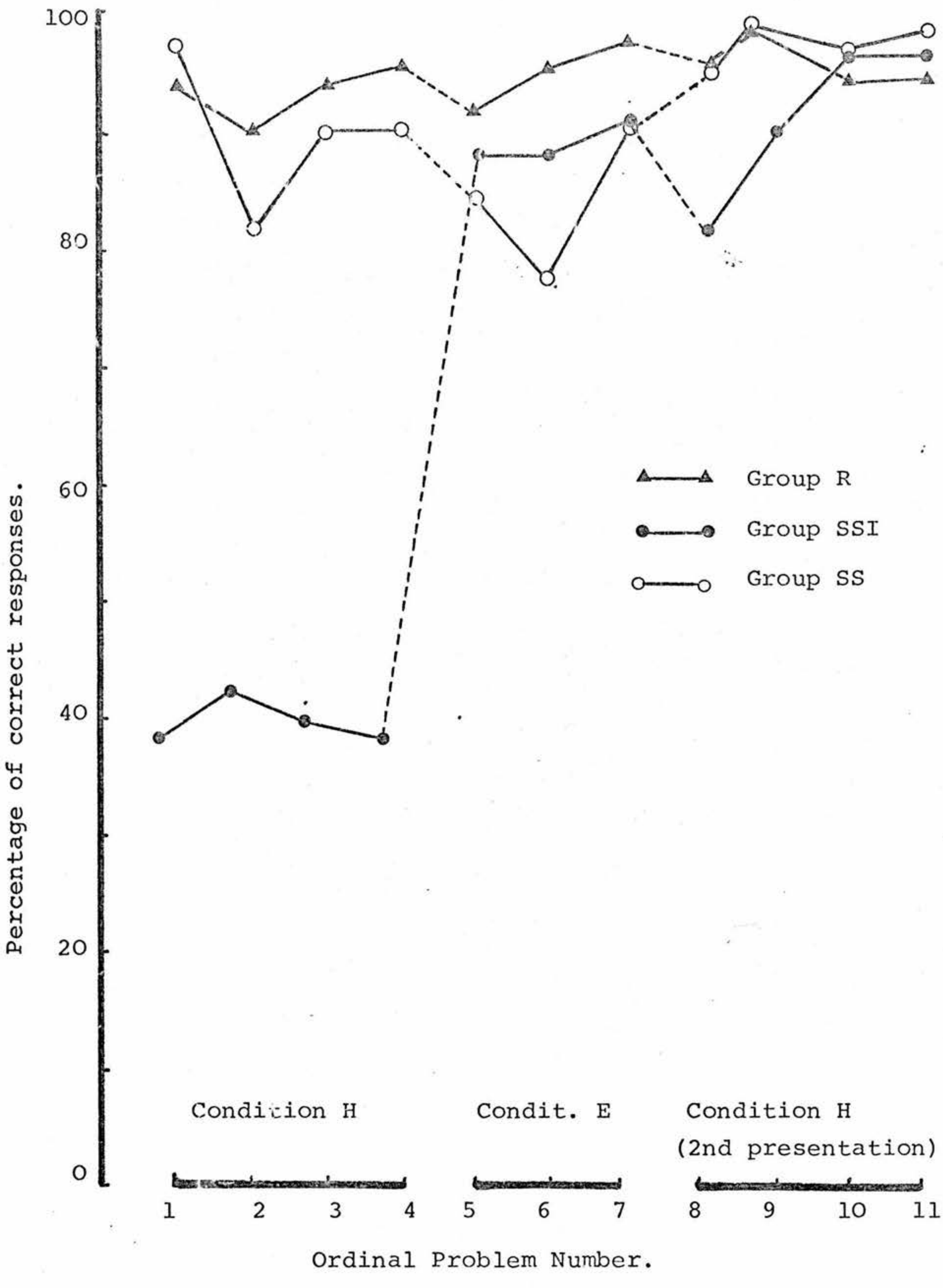


Figure 15 (2). The performance of the 3 groups during the fixed-trial learning-set of Experiment 11(2).

Source	SS	df	MS	F	p
Total	7769.28	71	-	-	-
Bet.Sub.	3149.78	8	-	-	-
Groups	3063.86	2	1531.93	124.81	0.001
Err-B	85.52	7	12.28	-	-
With.Sub.	4619.50	63	-	-	-
Treats	1800.00	1	1800.00	160.15	0.001
Subtreat.	16.59	3	5.54	0.48	0.2
G x T	2049.06	2	1024.53	91.15	0.001
G x St	92.44	6	15.41	1.34	0.2
T x St	54.21	3	18.07	1.27	0.2
G x T x S	76.39	6	12.73	0.89	0.2
Err-1	67.43	6	11.24	-	-
Err-2	206.49	18	11.47	-	-
Err-3	256.91	18	14.27	-	-

Table 27 (2). A table of the source of variance contibuted by the factors of Experiment 11(2).

Note: the deployment of the error terms is given in Table 'Treatments' represent the 2 blocks of identical 'hard' problems. 'Subtreatments' represent the ordinal problem numbers in each of these blocks examine the differences between the groups for Block 1 and for Block 2, separately. A significant F was produced for Block 1, but not for Block 2. The location of the difference is between Group R and Group SSI and between Group SS and Group SSI (using a t-test for differences between several means following a significant F, $p < 0.001$). The difference between Group R and Group SS was not significant. Table 28 (2) contains the Source Tables for these two alternative ways of looking at the data).

(A six-week period passed without any testing - for reasons unconnected with the experiment - following which Group SSI was retested on the first four problems that they encountered and eventually mastered. Since their performance was not good, in fact it had deteriorated to its original low level, the decision was taken to re-run the whole series of eleven problems again for this group. The results are recorded below. A sample problem given to both of the other groups indicated that this was not necessary in their case).

The performance of Group SSI on the second run is displayed in Table 29 (2) and Figure 16 (2). A Treatments-by-Subjects analysis of variance was carried out, comparing the first run with the second - Block 1 and 2 of the first run and Block 1 and 2 of the second run were taken as the four repeated treatments. The analysis showed a significant Treatments effect ($F = 82.17$; $df = 3,6$; $p < 0.001$ - See Table 30-2 for the Source Table) and the location of these differences was found using a t-test for differences between several means following a significant F, as above. Table 31 (2) displays this information. Clearly, the second run through was no different to the first in terms of level of performance.

A/

Group	MS	df	F	p
SSI	3750	1	305	<0.001
SS	91	1	7.66	<0.025
R	60	1	4.98	>0.1
Error	12.28	7	-	-

Comparison of the performance of the 3 groups of Experiment 11 (2) between the first and second exposure to the 'hard' problems - i.e. Block 1 and Block 2 .

Treatment	MS	df	F	p
Block 1	1792.60	2	146	<0.001
Block 2	56.49	2	4.59	>0.05
Error	12.28	7	-	-

Comparison of the performance of the 3 groups of Experiment 11 (2) during Block 1, and Block 2, separately.

Table 28 (2). Two alternative ways of interpretting following the significant interctive F of Table 27(2).

	Condition										
	H1				E			H2			
Subject	1	2	3	4	5	6	7	8	9	10	11
1	13	19	28	31	45	45	47	43	40	43	41
2	32	27	26	25	44	45	40	23	32	45	47
3	22	24	21	24	24	34	27	31	35	40	33
Mean	22	23	25	27	38	41	37	32	36	43	40
%Correct	46	48	52	56	79	85	77	67	75	90	83

Table 29 (2). The performance of Group SSI on the second run through the problems of Experiment 11(2).

Note: The measures are number of correct trials out 48.

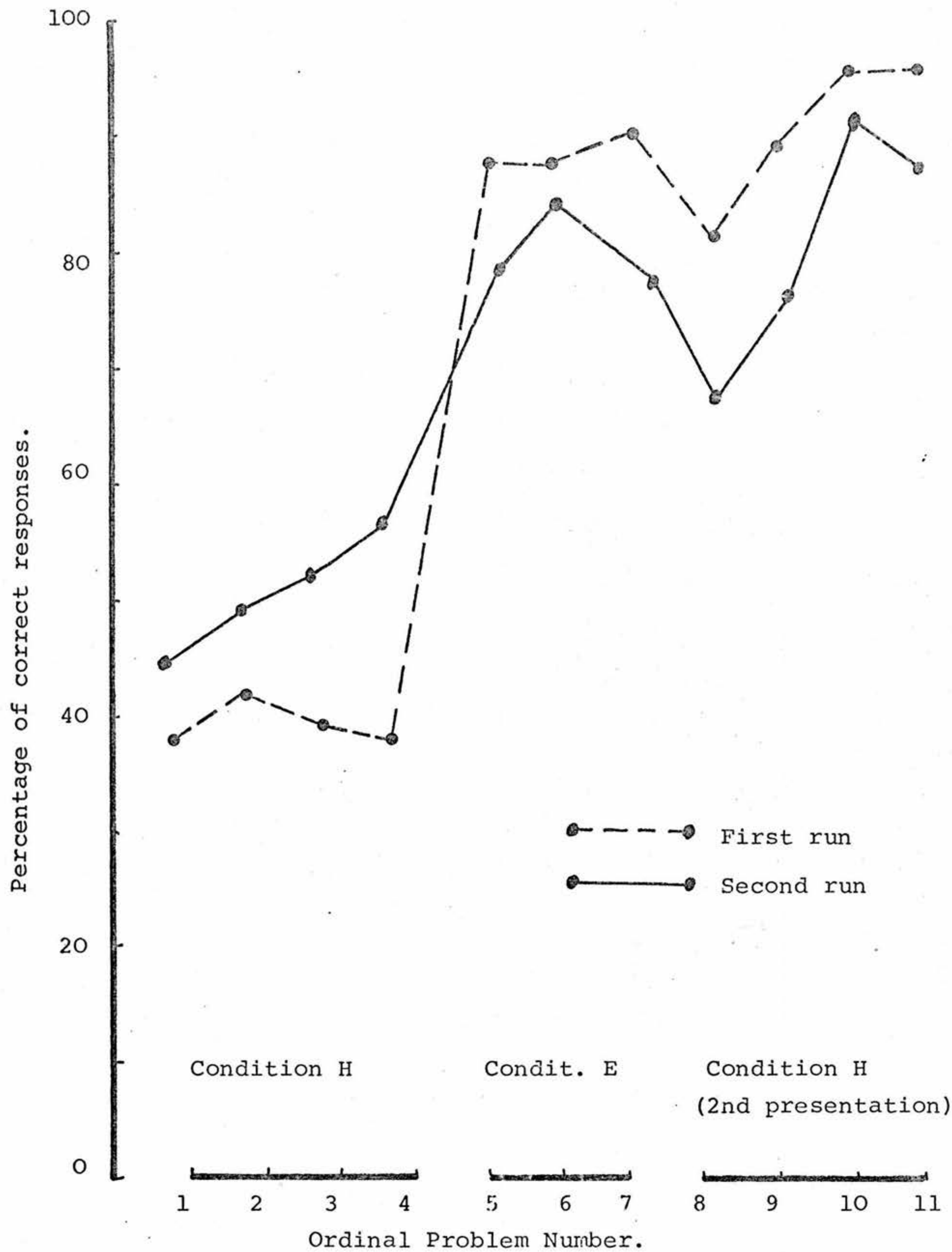


Figure 16 (2). The performance of Group SSI on the 11 ordinal problems of Experimenent 11(2), both the first and the second run through .

Source	SS	df	Ms	F	p
Total	1312.67	11	-	-	-
Subs	15.17	2	-	--	-
Treats	1266.67	3	422.22	82.17	0.001
Err	30.83	6	5.13	-	-

Table 30(2). Souce of the variance contibuted by the factors involved in the first and second run through the discrimination problems of Experiment 11(2).

1				
2	0.01			
3	x	0.01		
4	0.05	x	0.05	
	1	2	3	4

Table 31 (2). The location of the differences indicated by the significant F of Table 30(2).

Note: Treatment 1: Run 1, Block 1.

Treatment 2: Run 1, Block 2,

Treatment 3: Run 2, Block 1.

Treatment 4: Run 2, Block 2.

A finer-grain analysis was carried out on the first few trials of each problem, in terms of the percentage of correct responses made by Group SSI on the first trial and the number of perseverative errors made in the first ten trials of each problem. Table 32 (2) contains the information with respect to perseverative errors - significant perseveration is only detected in the hard problems (Condition H) on the first time of presentation. On the second time of presentation of this condition during the first run through, and the two presentations of the second run through, Condition H did not contain significant stimulus perseveration.

At no time during these problems, on the first or the second run through, did Group SSI respond at levels better than chance on the first trial (Binomial Test - $p > 0.2$ for a two-tail test).

DISCUSSION

The performance of Group R, clearly, indicates the wide applicability of the rule that Group R has acquired - it appears to be a true abstraction, emancipated from single stimulus values. The performance of Group SS is at a similar high level, with little indication of the instability which, in earlier experiments, was associated with the conservation of the single stimulus value. Indeed, the performance of both of these groups was quite exceptional on the fixed-trial learning-set problems: no subject failed to reach criterion on any of the discrimination problems. Further, in most cases, criterion was met during the first few trials.

The performance of Group SSI, however, tells a different story. Their total/

Condition	Errors		p-value
	Perseverative	Non-Perseverative	
H1 - Run 1	42	21	=0.01
H2 - Run 1	21	15	>0.1
H1 - Run 2	31	29	>0.1
H2 - Run 2	31	19	>0.1

Table 32(2). An analysis of the errors with respect to stimulus perseveration during the 4 occasions that the hard problems of Experiment 11(2) were presented to Group SSI.

Note: the p-values were derived using a Binomial Test, and are 2-tailed.

total failure on the first four problems of the series indicates that it is unlikely that they have acquired a rule 'middle' as the generalization testing of Experiment 8 (2) has suggested. Their failure cannot be due to an inability to discriminate between the stimuli of these triads in sensory terms, since the subjects of the other two groups had no trouble in this respect. The remarkable recovery by Group SSI, improving from chance responding on the first four problems (hard) to criterion-behaviour on the next three problems (easy), was not expected. The reasons for this improvement are not clear - it appears unlikely that the cause is the change in sensory difficulty, per se, since no differential difficulty is shown by the other two groups, as noted above. Indeed, there is a slight decrease in performance of Group SS between these two conditions. The further surprising result is that on the rerun of the hard problems (note - these are the same hard problems as experienced at the beginning of the fixed-trial learning-set series), the recovery of Group SSI is maintained, and their performance is indistinguishable from the other groups (at least, in these gross terms). The results show that during the initial trials of the first presentation of the hard problems, the cause of error is largely due to perseveration errors, whereas during the second presentation, and indeed, in subsequent presentations in the rerun, this source of error was not found to be a significant factor. This suggests several points:

There appears to be some evidence that subjects of Group SSI do respond to specific stimulus values (i.e. they perseverate following problem change) and, indeed, they do appear to be learning about specific stimulus values by the end of each problem of the first block of hard problems,/

problems, otherwise there would be no perseveration! Also, following experience with the first presentation of the easy problems, perseveration disappears, and yet the performance measures indicate that the problems are easily learned. The answer cannot be that some rule has developed (similar to that of Group R) since, at no time does Group SSI's performance rise above chance on the first trial of these problems (which is the only secure measure of a rule of abstraction, rather than any other type of rule - for example a Win-Stay, Lose-Shift strategy).

A possible explanation of the changes seen in the performance of Group SSI might lie in the proposition that it is due to Proactive Interference that specific stimulus values are poorly retained from trial to trial during the first presentation of the hard problems. The fact that proactive effects can be demonstrated in similar situations has been shown with non-humans by Stretch, McGonigle and Morton 1963 and Mackintosh, McGonigle, Holgate and Vandever 1969. Interference should be particularly strong when the stimuli are not highly discriminable from one another (as in the hard problems). It is not surprising, therefore, that upon transition to the easy problems, there is an improvement in the level of performance, since the interference would be much reduced. What remains unclear, however, is why this improvement is maintained when the hard problems are rerun. Whether this effect is due to an 'acquired distinctiveness' of cues as described by Lawrence (1949) and/or due to the re-establishment of strong stimulus 'anchor points' along the continuum of 'size' which attenuate the effect of proactive interference, is not fully clear at this point. There are, however, indications that monkeys in Group SSI do/

do use such anchor points: when previously presented with Triads ABD and BDE in equivalence tests following training on Triads ABC and CDE (with Stimulus B and C rewarded) subjects selectively chose Stimulus B or D as a function of whether Stimulus A or E was also present. When Triad ABD was presented, Stimulus B was chosen and when Triad BDE was presented, subjects chose Stimulus D. As both Stimulus B and D were rewarded in their respective triads, the selectivity of the responses to Stimulus B and D must indicate the use of other stimuli in the series to help identify the rewarded one. This conclusion is borne out by the results of Experiment 2 (2), where pre-exposure with stimuli outside the range of the training stimuli had an adverse effect upon subsequent choice behaviour. With highly discriminable anchor stimuli effectively partitioning the 'size' continuum, the (short-term) effects of proactive interference may well be attenuated. Some support for this posture is gained from the human literature, Vernon writes with respect to the judgement of such attributes as size (Vernon 1962, page 149):

> ". . . it constitutes one more example of the attempt to cope with an unfamiliar situation involving a particularly difficult type of judgement by employing all previous relevant experience as a framework to which the present perception may be anchored, and by means of which it may be stabilized."

In the case of the current experiment, the stimulus triads of the easy condition allow the subjects to partition the size continuum such that the "judgements of a difficult type" can be, using the refurbished anchors, accommodated. In the case of the rerun of problems (following the six-week lay-off), the poor performance on the hard problems prior to introduction of the easy problems is interpreted in terms of these anchor/

anchor points becoming less effective. Following the presentation of the easy problems for the second time, the anchor points are re-established and discrimination within the hard problems becomes possible. The lack of stimulus perseveration in these problems is taken as an indication that the monkeys no longer try to solve each new problem on the basis information derived from the previous problem (and producing perseveration) but on the basis of the reward contingencies operating in each new situation. That they become quite sophisticated suggests that, apart from the anchor effects, an effective response strategy has emerged, perhaps of the type Win-Stay, Lose-Shift which is emancipated from stimulus dimensions.

In summary, it appears that Group R has developed a general rule 'largest'; Group SS is able to conserve a specific stimulus value and it appears likely that Group SSI have not learned a rule in the same way as Group R but are, indeed, specific stimulus learners as are Group SS. However, in this respect, the results (for Group SSI) are not conclusive. Further, it appears that successful discrimination in the current case (for Group SSI) depends upon the partitioning of the size continuum by several highly discriminable anchor points.

EXPERIMENT 12 (2)

INTRODUCTION

The results of Experiment 11 (2), and other previous experiments, strongly support the view that Group R have learned a rule of relation between stimuli that is emancipated from their specific values, but not from the dimension of 'size' - and this is of wide applicability. It appears, also, that Group SS have, indeed, learned to conserve the specific 'size' of a stimulus (Stimulus C) from any combination of it and other stimuli. Thus, in the 'classical' sense, these two groups display relational and absolute learning. The results of Experiment 11 (2), far from supporting the view that Group SSI have acquired a rule 'intermediate' (as previous experiments did, perhaps, suggest), appear to suggest that they have learned to conserve specific stimulus values that differ from problem to problem. The suggestion is that in their learning, they reflect that of Group SS rather than Group R - even though extensive opportunity was given for them to acquire a rule 'intermediate'.

The current experiment is designed to determine whether or not Group SSI behaves like Group SS or Group R. It is a logical point, so it was argued in Chapter 1, that the value of a single stimulus is not an absolute, but a relative entity - the identity of a single stimulus is a function of that stimulus and some referencing system. If it is the case that specific stimulus values are relative entities, then the question arises Relative to What? In the case of Group R the relations involved/

involved appear to be between the stimuli that are simultaneously presented. In the case of Group SS, however, (and the current suggestion is that this also applies to Group SSI) there are two possible contenders - exocentric references involving the environment (for example, 'as big as that wall') and egocentric references involving the parts of the subjects body (for example, 'as big as my hand'). Elimination of this visual context should interfere with the referencing system involving the identification of specific stimulus values to the point that identification should be impossible, whilst leaving the referencing system in which stimuli are identified as 'larger', for example, intact and thus allowing identification to continue. In terms of the current experimental series, elimination of the visual context should not disrupt the discrimination acquired by Group R, but should seriously impair the ability of Group SS to conserve their specific stimulus value. Further, the performance of Group SSI, in such a situation, should indicate whether or not its subjects have acquired a rule (of the type exhibited by Group R) or whether they have solved the discriminations in the same way as Group SS.

The current experiment contains trials in which the visual context is eliminated, and the questions raised, above, are put to the test.

METHOD

Subjects

Subjects of Group R (n=3), Group SSI (n=3) and Group SS (n=3) took part in this experiment.

Apparatus /

Apparatus

The same W.G.T.A. and matt red three-stimulus tray as was used in the previous experiment was used in Experiment 12 (2). However, lighting conditions were varied throughout the experiment. On some trials, the test-room light positioned above the stimulus arena of the W.G.T.A. was switched off, rendering the apparatus and the small test-room in total darkness, since the room was perfectly light-tight and windowless. A further piece of apparatus was constructed for use in the current experiment - a light box (18" x 6" x 6") lined with aluminium foil and containing a 40 watt neon light which was used in conjunction with the modified stimuli described below. With the lid of this box closed, no light was visible from the outside.

Stimuli

The five stimuli of the basic stimulus pool were used in this experiment. Modified versions of these were constructed by coating the surface of cubes identical to the basic stimulus pool with several coats of commercial jewellers' luminous paint (non-poisonous and non-radioactive) spread evenly to produce a relatively featureless, pale green luminous surface in the dark. Several identical versions were constructed from each parent stimulus of the basic stimulus pool.

These luminous stimuli were kept ready and 'charged' in the light box, since the paint that was used was not self-luminous but derived its light-emitting quality from its ability to, effectively, absorb energy from light waves and emit it at some later time. The 'charging' process took less than ten seconds with the light box described, and their/

their shape was unambiguously perceptible for at least three minutes, to the human observer (when removed from the box and placed in darkness). The volume of light emitted was not sufficient for a dark adapted human observer to distinguish features of the stimulus arena or the surface of the tray.

Procedure and Design

Testing was carried out for four consecutive days. Each day's testing began with twelve differentially-rewarded training trials following the general procedure of Experiment 7 (2). A further series of twelve trials was given provided that the subjects made no more than one error during the first twelve trials of the day, otherwise they were subjected to retraining as described in previous experiments. During the second twelve trials of the day, the lighting in the testroom was switched off, and the luminous versions of the basic stimulus pool were used in place of the normal stimuli, themselves - Condition L. The procedure during Condition L was identical to that of the first twelve trials of the day (with the exception of different stimuli) including the differential reward and the implementation of a correcting procedure. Following these trials of Condition L, a further six trials were given under conditions identical to those of the first twelve trials of the day, to determine whether the highly novel Condition L had, subsequently, been disruptive. This daily procedure was carried out for four days, during which time forty-eight trials were given under the luminous condition.

RESULTS

Concern/

Concern that subjects would not be disposed to approach and displace such luminous stimuli proved to be groundless. Response times during the first day's session were atypically long (up to thirty seconds with the odd trial having a response time a little longer), but by the second day of testing most subjects had response times of approximately five seconds, and no subject was worse than ten seconds. By the final day of testing response times were indistinguishable from those of conventional trials. Concern that subjects would find difficulty in retrieving the reward, after the correct stimulus had been responded to, proved to be equally groundless - their success rate being high after the first few trials.

The performance of the three groups during the luminous condition is displayed in Table 33 (2). Clearly, there was good positive transfer by Group R to the trial of Condition L, each subject making significantly more errors than would be expected from chance responding (Binomial Test - $p<0.01$, $p<0.002$, $p<0.002$ for a two-tail test). On This measure, no subject of either of the other two groups showed such deviation from chance responding (Binomial Test - $p>0.6$ for a two-tail test, for the best subject).

A two-Factor Mixed Design Analysis of Variance with Repeated Measures on one Factor was carried out on the scores of Group SSI and Group SS, to examine whether there was any difference between them (Group R was excluded since its variance would clearly violate one of the assumptions of it being included in such an analysis.) Table 34 (2) displays the Source Table of this analysis, and it can be seen that none of the F-values were significant. This indicates that the two groups/

Group	Subjects	Block of 12 Trials					
		1	2	3	4	Total	% Error
SSI	1	10	8	8	7	33	69
	2	7	6	5	8	26	54
	3	6	5	7	6	24	50
	Total	23	19	20	21	83	
	Mean	8	6	7	7	28	58
SS	4	9	8	5	7	29	60
	5	6	7	3	5	21	44
	6	6	5	5	8	24	50
	Total	21	20	13	20	74	
	Mean	7	7	4	7	25	52
R	7	1	1	1	0	3	6
	8	0	1	1	1	3	6
	9	2	1	2	1	6	12
	Total	3	3	4	2	12	
	Mean	1	1	1	1	4	8

Table 33 (2). Errors made by the 3 groups during the luminous transfer testing of Experiment 12 (2).

Note: Chance responding would produce 66% error.

Source	SS	*DF*	MS	*F*	*p*
Total	1081.00	23	-	-	-
Bet.Subs	22.71	5	-	-	-
Groups	3.37	1	3.37	0.74	0.10
Error	19.31	4	4.83	-	-
With.Subs	1058.32	18	-	-	-
Blocks	10.79	3	3.59	0.04	0.10
Gr x Bs	5.79	3	1.9	0.02	0.10
Error	1041.01	12	86.81	-	-

Table 34 (2). Source Table of the variance contributed by the various factors of Experiment 12 (2).

groups performed in a similar manner and that the performance over the four days testing did not change.

The three groups made negligible errors on the six trials following Condition L.

DISCUSSION

The highly novel testing procedure was not generally disruptive of choice behaviour since the subjects of Group R were scarcely affected by the change. The result is consistent with the view that these subjects have acquired a rule of relation which exists between the simultaneously presented stimuli, and makes no reference to the fixtures of the environment in its operation (save the stimuli, themselves), since such fixtures have been 'removed' - the performance of Group SS, however, was seriously disrupted, indeed, their responding was never better than chance. This strongly supports the view, already advanced and discussed in Chapter 1, that specific stimulus values are identified in relation to referents of the environment and are not 'self contained'. When such referents are removed from the choice situation, so-called absolute responding is impossible since identification is prevented.

The fact that the performance of Group SSI is indistinguishable from that of Group SS (thus, unlike that of Group R), strongly suggests that the conclusion derived from the results of the previous experiment is the more reasonable one - that Group SSI, even though given an extensive opportunity to acquire a rule 'intermediate', have been conserving/

conserving single stimulus values in a manner similar to (if not identical with) Group SS.

Whilst the current experiment is highly consistent with the view that fixtures of the environment (be this the exocentric or the visual part of the egocentric environment) are of prime importance in the identification of specific stimulus values, it offers no suggestions as to what these may be. Nevertheless, the fundamental issue raised in Chapter 1 with respect to so-called absolute responding is somewhat clearer - and the theoretical position which was developed is supported.

The following experiment represents an attempt to determine whether or not the stimulus tray, itself, is implicated in the referencing system for so-called absolute responding.

E X P E R I M E N T 13 (2)

INTRODUCTION

The previous experiment offers evidence in support of the contention that specific stimulus values are identified in relation to some visual reference - either exocentric or egocentric - which is not part of the discriminanda. Since the stimulus tray is the nearest 'object' to the discriminanda (indeed they sit upon it), the hypothesis is advanced that stimuli are judged by Group SS and Group SSI in relation to that. Thus, by selectively manipulating the size of the tray (as a referent) the identified 'size' of individual stimuli should be commensurably changed. Such a manipulation, if the tray is so implicated, should disrupt the choice behaviour of Group SS and Group SSI, but not affect that of Group R.

The current experiment involves such a procedure. However, in embarking upon this investigation, the author is aware that many other potentially important referents remain unchanged, and are present. This being the case, the involvement of the tray would, perhaps, need to be exclusive before its alteration produced a corresponding change in the choice behaviour of Group SS and SSI. Nevertheless, its involvement needs to be assessed.

METHOD

Subjects

Group R (n=3), Group SSI (n=3) and Group SS (n=3) took part in Experiment/

Experiment 13 (2).

Apparatus

The same W.G.T.A. was used as was used in the previous experiments. Two different three-presentation stimulus trays were used. An identical matt red tray as was used in the previous experiment was used in the current one, as well as one which was painted the same mid-grey as the W.G.T.A. with the exception of that area inside a 1" border around the upper surface, which was painted the same matt red as the conventional tray.

Stimuli

The five stimuli from the basic stimulus pool were used.

Procedure and Design

The first ten trials of the day's testing consisted of differentially rewarded training trials following the general procedure for the presentation of triads A v B v C and C v D v E, using the matt red stimulus tray, as outlined in Experiment 7 (2). Following these ten trials, a series of twenty trials were given of which ten were non-differentially rewarded equivalence trials and ten were randomly interpolated training trials. The training trials were conducted according to the procedure of the first ten trials of the day. The equivalence trials were given using the tray with the 1" grey border.

Testing was carried out for one day, and subjects had to satisfy the usual criterion before being allowed to continue into the equivalence testing session.

RESULTS/

RESULTS

All subjects of the three groups showed high positive transfer to the equivalence trials. In fact, only one 'error' was recorded during these trials - by Subject two of Group SSI. The results have not been tabulated.

DISCUSSION

It seems unlikely that the stimulus tray is of prime importance in the identification of specific stimulus values, despite its close proximity to the discriminanda. However, as discussed above, many other potential referents remain unchanged, and it appears that at least one of these is being used. Indeed, the referent may be the whole, organized stimulus arena, in which case, changing particular features of this arena ought to have negligible effect. Overall magnification or minification of the arena, in this case, would be the only suitable test. Such a procedure does not produce the severe technical difficulties that distortions of visual egocentric referents entail. However, if the referencing systems are to be fully identified, such technical difficulties need be overcome.

EXPERIMENT 14 (2)

INTRODUCTION

The previous experiment involving luminous testing has demonstrated that specific stimulus values are identified in relation to some visual referent in the exocentric or egocentric environment. Experiment 13 (2) represented a single attempt to determine the identity of the referent, and the role of the stimulus tray in such a process was assessed. Manipulation of the size information of the tray was carried out, but it appeared to have no effect upon the discrimination of the two groups closely involved. The further identification of the referents must be left to future research projects since the technical problems render the asking of the necessary questions outwith the scope of the present undertaking in terms of both equipment and time, However, the current author sees the identification of such referents and the relative roles of the exocentric and egocentric environments as being of crucial importance in the further development of explanations of discrimination learning, and perception in general.

The current experiment examines the relation between stimuli and their referents, further, but this time by manipulating the stimuli rather than the environmental referents.

METHOD

Subjects

Group/

Group R (n=3), Group SSI (n=3) and Group SS (n=3) took part in the current experiment.

Apparatus

The same W.G.T.A. was used as before with the matt red stimulus tray.

Stimuli

The five stimuli of the basic stimulus pool were used (Stimulus A, B, C, D, and E), along with stimuli modified in two ways.

Modification 1. Cuboid stimuli were painted matt red (the same as the tray) and a $\frac{1}{4}$" matt white border was painted on each of the faces of the cubes. This was called Condition BW (= Border White).

Modification 2. Cuboid stimuli were painted matt white with a $\frac{1}{4}$" border of matt red on each face. This was called Condition BR (=Border Red). Versions of each of the five 'parent' stimuli were, thus, constructed.

Procedure and Design

The structure of the day's testing was identical to that of the previous experiment, except for the fact that the matt red stimulus tray was used throughout and the equivalence stimuli were not the same. Testing was carried out for four consecutive days with the Condition BR and Condition BW presented on alternate days. The order of alternation was partially counterbalanced within each group. Thus, each condition was represented to each subject a total of twenty trials (i.e. ten trials for each triad).

RESULTS/

Group	Subjects	Equivalence Triads					
		A	B	C	C	D	E
SSI	1	5	4	1	9	1	0
	2	6	1	3	9	1	0
	3	7	1	2	9	1	0
	Total	18	6	6	27	3	0
	Mean	6	2	2	9	1	0
SS	4	3	5	2	10	0	0
	5	4	6	0	10	0	0
	6	4	4	2	10	0	0
	Total	11	15	4	30	0	0
	Mean	4	5	1	10	0	0
R	7	10	0	0	10	0	0
	8	10	0	0	10	0	0
	9	10	0	0	10	0	0
	Total	30	0	0	30	0	0
	Mean	10	0	0	10	0	0

Table 35 (2). Distribution of the responses to the 2 equivalence testing triads of Experiment 14 (2).

- Condition BR -

RESULTS

All groups showed high positive transfer from the training trials to the equivalence trials of Condition BW. In fact, only one subject of Group R and one of Group SSI made an 'error'.

Table 35 (2) displays the distribution of the choices during the equivalence trials of Condition BR. Visual inspection indicates that there was perfect positive transfer on this condition by Group R, but not by Group SSI and Group SS. Rather than respond to Stimulus (B) of triad (A) v (B) v (C) and to (D) of triad (C) v (D) v (E) <u>every</u> subject of Group SSI responded to (A) and (C), respectively, more than to any other stimulus. With each of these triads, the performance of Group SSI represents a significant deviation from chance responding (<u>Chi</u>-square one-sample test - <u>Chi</u>-square = 9.6; df = 2; $p < 0.01$ for triad (A) v (B) v (C) and <u>Chi</u>-square = 42.6; df = 2; $p < 0.001$ for triad (C) v (D) v (E). The performance of Group SS on triad (A) v (B) v (C) showed similar effects in that Stimulus (B) was chosen rather than (C), representing a deviation from chance responding (<u>Chi</u>-square one-sample test - <u>Chi</u>-square = 6.2; df = 2; $p < 0.05$). Their performance on the smaller triad was perfectly consistent with their performance on the corresponding training trials and statistical assessment is unnecessary.

DISCUSSION

In the equivalence testing subjects of Group R chose the largest stimuli of each triad, as was expected. For all the alterations to the stimuli, the/

the relationships between the stimuli remained unaltered, as did the choice behaviour. This is consistent with the results of previous experiments, involving this group.

The performance of the two groups involved with conserving specific stimulus values, however, was considerably influenced by Condition BR but not by BW. In the case of the latter condition, the relationship between individual stimuli and whatever referent is being used remains unchanged and the choice behaviour is unaffected. However, in the case of Condition BR, the relationship between the individual stimuli and their referent is changed (in a way analogous to the reduction in apparent size of the stimulus tray in Experiment 13 (2) and the choice behaviour of the groups conserving specific stimulus values is correspondingly affected. This selective disruption (selective in terms of groups and the direction of disruptive shifts in the triads) is not a function of the testing procedure, as such, otherwise Group R would have been affected.

The results of the current experiment give further support to the view that Group SS and SSI have the same basis for discrimination, that is different from Group R.

E X P E R I M E N T 15 (2)

INTRODUCTION

The theoretical position developed in Chapter 1 introduced the logical necessity of specifying or identifying specific stimulus values in terms of some referent in the environment. In the case of the current series of experiments, visual referents have been considered - in the subject's exocentric and egocentric visual environment (for example, the stimulus arena's walls and the subject's hands, respectively). However, other referents were also considered - those in which visual information is confined to the stimulus-to-be-conserved, itself, but where other information (i.e. the referent) is forthcoming from another source which is non-visual. Such sources were the subject's 'body sense' or 'body space' - sources which would be difficult to measure in an experimental way. If such referents do exist, then prolonged training on the luminous problems used thus far ought to permit the subject to come to conserve specific stimulus values (even though other visual referents are absent as the previous experiment involving luminous testing).

The current experiment serves to give the groups involved in specific stimulus conservation the opportunity to learn about specific luminous stimuli, with prolonged differentially rewarded testing - in the expectation that if 'internal' referents can operate, then specific stimulus learning should emerge.

METHOD/

METHOD

Subjects

Nine subjects took part in the current experiment: Group R (n=3), Group SS (n=3) and Group SSI (n=3).

Apparatus

The same W.G.T.A. and stimulus tray was used as in previous testing involving luminous stimuli. The light box was also used. The whole of the experiment was conducted in darkness in the light-tight testing room.

Stimuli

Luminous versions of the extended stimulus pool were constructed as before. Several identical exemplars of each stimulus was produced. Only self-luminous stimuli were used in the current experiment.

Procedure and Design

Luminous versions of the seven different discrimination problems used in Experiment 11 (2) were used in the current experiment. The general testing procedure and the reward contingencies were the same save that testing was carried out in the dark, and until an 18/20 criterion of acquisition was met (if at all possible). Forty-eight trials per day were given with a correcting procedure.

Unlike Experiment 11 (2), the stimulus triads of the easy condition (Condition E) were presented before those of the hard condition (Condition H). The order of presentation was counterbalanced, as before,/

before, as far as possible using 3 x 3 and 4 x 4 Latin Squares. And subjects of Group SS were matched with subjects of Group R, and both were matched as far as possible with the subjects of Group SSI - in terms of the order of presentation of different problems.

RESULTS

Table 36 (2) records the number of errors to criterion for the nine subjects. Visual inspection shows that Group R had little difficulty with the discriminations, making negligible errors even on Condition H. Group SS and Group SSI showed poor transfer to the luminous testing. A two-Factor Mixed Design: Repeated Measures on one-Factor showed that their was no difference between the performance of these two groups ($F = 0.24$; $df = 1,4$; $p > 0.2$; for the groups effect - $F = 1.27$; $df = 6,24$; $p > 0.1$; for the group x problem interaction). The problems effect reached significance ($F = 2.60$; $df = 6,24$; $p < 0.05$) but has not been interpreted since it is of little current interest. Note that Group R did not take part in the analysis of variance, apart from the fact that a visual inspection makes this totally unnecessary, the very low variance of the scores of the group in relation to those of Group SS and SSI violate the assumption of homogeneity of variance. The source table for this analysis is recorded in Table 37 (2).

DISCUSSION

As expected, the performance of Group R was as good as in the normal lighting conditions, finally underlining the fact that their basis for responding resides within the discriminanda, themselves. The other two/

Group	Sub.	Condition E 1	2	3	Condition H 4	5	6	7
SSI	1	33	34	27	50	11	21	30
	2	61	13	10	22	28	18	20
	3	68	5	2	5	14	9	19
	Mn	54	17	13	21	18	16	23
SS	4	50	13	16	47	22	13	21
	5	26	30	27	17	29	18	19
	6	21	64	25	23	30	12	14
	Mn	32	36	23	29	27	14	18
R	7	2	0	0	0	2	0	0
	8	0	0	0	3	3	0	0
	9	0	0	0	2	0	1	0
	Mn	1	0	0	2	2	0	0

Table 36 (2). Errors to criterion in the transfer testing under luminous conditions of Experiment 15(2).

Source	SS	DF	MS	F	p
Total	9908.98	41	-	-	-
Bet.Sub.	582.40	5	-	-	-
Groups	32.60	1	32.62	0.24	0.1
Err	549.82	4	137.45	-	-
With.Sb.	9326.57	36	-	-	-
Probs	3074.81	6	512.47	2.59	0.05
P x G	1504.93	6	250.01	1.27	0.1
Err	4746	24	197.78	-	-

Table 37 (2). The source of variance contibuted by the factors of Experiment 15 (2).

two groups, however, showed the type of choice behaviour demonstrated in earlier luminous testing. However, each subject did manage to achieve criterion-behaviour under these conditions of test which supports the proposition involving internal (or, at least, non-visual) referents. The fact that there was no significant differences between these two groups supports the view that they have a common basis for discriminating.

The luminous testing trials of the current experiment and those of Experiment 12 (2) suggest that the two basic classes of referents that it is proposed could be (indeed, need be) involved in the identification of single specific stimulus values, do exist.

THE RE-COMBINATION OF GROUP SS AND GROUP SSI

The package of experiments, thus far, gives a clear indication that squirrel monkeys are able to learn about specific stimulus values in the discrimination of size (i.e. Group SS). Further, Group SSI (even though they were given the opportunity of acquiring a rule in a manner analogous to Group R) have shown themselves to be specific stimulus learners, too. For the final experiment in the size series, these two groups are combined. Before Experiment 16 (2), therefore, Group SSI were given the opportunity to learn about specific stimulus values which were not 'intermediate' in the presented triad.

Thirty differentially-rewarded trials were given per day with correction procedure. Training was carried out up to the 18/20 criterion using the same procedure as Experiment 11 (2). Three consecutive problems were given in a counterbalanced order - Stimulus Triad A 'CD', AB' D and BD'E. Either the largest or the smallest stimulus was rewarded per problem (never the intermediate), with the constraint that no specific stimulus was reinforced for any subject on two consecutive problems. Criterion was met on every problem by every subject with a mean number of errors to criterion of 14. Group SSI, thus, have little difficulty with the type of specific stimulus learning required of Group SS. The re-combined Group is called Group SS'.

E X P E R I M E N T 16 (2)

INTRODUCTION

The final experiment in the 'size' series is addressed to the referents that are used in the identifying of stimuli of particular values. For this reason Group R do not take part, since they have shown themselves to be emancipated from referents outside the stimuli, themselves.

The specific stimulus learners comprising the new Group SS', have shown that in identifying specific stimuli in the light, they use referents outside of the discriminanda, that are visual (since by making them invisible, the discrimination is lost). Further, they have shown that with prolonged training, they are able to use other referencing systems in order to discriminate when these visual referents are absent. The current experiment is designed to assess these two types of referencing systems, further.

Subjects will be asked to conserve a specific stimulus value in either the light condition or the luminous condition and the effects of <u>within session</u> problem change and condition change will be measured. It is already known from previous experiments that specific stimulus learners cannot transfer from light-testing easily to luminous-testing conditions with problems involving two stimulus triads. Can such learners accomplish transfer when the problem is made more simple, when only one triad is used? And, further, when learning of specific stimulus values does take place in the dark, is the referencing system that is used available for use when testing is continued in the light?

METHOD/

METHOD

Subjects

The subjects of Group R did not take part in the current experiment. Subjects of Group SS and the newly-formed Group SS' were combined, and abandoned their group identity. One subject (subject three) had to be withdrawn from the experiment due to illness.

Apparatus

The same W.G.T.A. as has been used throughout this series of experiments was used for Experiment 16 (2), and the matt red three-stimulus presentation tray was also used. For some trials, the testing conditions required the lighting to be switched off, for others the lighting remained on. Trials which were administered in the dark required the use of the light box.

Stimuli

The same stimulus triad was used throughout this experiment - triad A' v B' v D. Both the normal white version was constructed, as well as the luminous version (as detailed in previous experiments). In keeping with previous experiments, many identical replicas of each stimulus was constructed and freely interchanged from trial to trial.

Procedure and Design

Subjects were tested for eight consecutive days and were given seventy trials per day. Trials were administered according to the general testing procedure using differential reward and a correcting procedure. The/

The testing of any day was divided into two concatenating sessions of length thirty-five trials - Session One and Session Two. The reward contingency for any subject was changed from day to day, at the start of the day's testing, thus producing a nearly-new problem on trial one of each of the eight days of testing (since only one stimulus triad was used, some reward contingencies were used three times - but a particular reward contingency was never given on adjacent days). At the end of Session One (i.e. trial thirty-five of the day) the reward contingency in operation for any subject was either (i) changed and the new one used for the next thirty-five trials of Session Two, or, (ii) it remained unchanged and operated for the whole of Session Two, as well. These two conditions were referred to as Condition C (= change) and Condition N (= no change). Further, the lighting conditions for the two sessions were manipulated in the following way: the testing room light was switched either off or on for the whole of Session One (using the luminous stimuli where appropriate), and this was repeated for Session Two. Thus, there were four possible combinations of lighting conditions L-L, D-D, L-D and D-L where in the case of L-D, L refers to Session One with the light on and the normal white stimuli used to make up the triad and D refers to Session Two with the light off (D = dark) and the luminous stimuli making up the triad. For each of these four conditions, however, either Condition C or Condition N could be in vogue, producing a total of eight possible combinations of these factors. Table 38 (2) displays the eight conditions used in the current experiment, and the nomenclature used. Each of the six subjects of the experiment received each of the eight conditions, and counterbalancing for the order of presentation of the conditions/

Condition		Reward Contingency		Lighting Conditions			
No.	Code	Change	No-change	Light-Light	Light-Dark	Dark-Dark	Dark-Light
1	C/LL	X		X			
2	C/LD	X			X		
3	C/DD	X				X	
4	C/DL	X					X
5	N/LL		X	X			
6	N/LD		X		X		
7	N/DD		X			X	
8	N/DL		X				X

Table38 (2). The 8 conditions of used in the testing of Experiment 16 (2).

Note: Condition 2 referred to with the descriptive code C/LD, represents the condition in which testing in the light is carried out during Session 1, at the end of Session 1 the reward contingency in changed, and testing during Session 2 is carried out in the dark with luminous stimuli.

conditions was partially achieved using six rows of an 8 x 8 Latin Square. Testing was carried out for eight days, each subject receiving one condition per day.

RESULTS

Table 39 (2) displays the total number of errors made by the subjects on each of the seven blocks of five trials for Session One and Session Two, for each of the eight conditions of test. The representative means (since five subjects contributed to some conditions and six to others - due to the withdrawal of one subject part way through the experiment) are plotted for each of the conditions in Figures 17-20 (2). Figure 17 (2) displays the graph for Condition N/LL and C/LL. In Condition N/LL, asymptotic performance is reached during Session One and the whole of the performance in Session Two is at this asymptote. In Condition C/LL, however, the reward contingency is changed (analogous to a reversal in conventional two-stimulus presentation discriminations) and the subjects change from asymptotic performance at the end of Session One to very poor performance at the start of Session Two. Figure 18 (2) displays the graphs for Condition N/DD and Condition C/DD, which are similar to those of Figure 17 (2), except for the fact that learning appears to be slower in the dark condition than in the light. Thus, in Session One, asymptotic performance is not reached before Session Two is begun. In fact, the graph representing Condition N/DD indicates that only at the end of Session Two, is the region of asymptote reached. Nevertheless, the graph representing Condition C/DD does show a marked discontinuity at the Session One, Two boundary where the/

Condition	Total Errors in Blocks of 5 Trials													
	Session 1							Session 2						
	1	2	3	4	5	6	7	1	2	3	4	5	6	7
C/LL	14	7	8	6	4	2	2	18	16	12	9	4	10	5
C/LD	13	8	13	4	3	3	2	12	9	9	10	10	9	7
C/DD	15	13	11	15	10	11	8	15	10	10	9	6	6	5
C/DL	17	13	11	10	8	10	9	20	11	13	13	9	2	4
N/LL	15	6	12	6	1	3	1	3	3	2	2	2	1	1
N/LD	10	12	9	7	5	2	2	10	13	12	9	8	6	4
N/DD	15	11	13	13	10	12	8	7	9	6	11	3	7	4
N/DL	13	10	12	12	9	12	6	7	7	4	6	4	2	2

Table 39 (2). Total number of errors made by the subjects of Experiment 1b (2) in the 5-trial blocks during each of the 8 testing conditions.

Note: Subject 3 only contributed to the totals of Condition C/DD and C/DL before being withdrawn from the experiment.

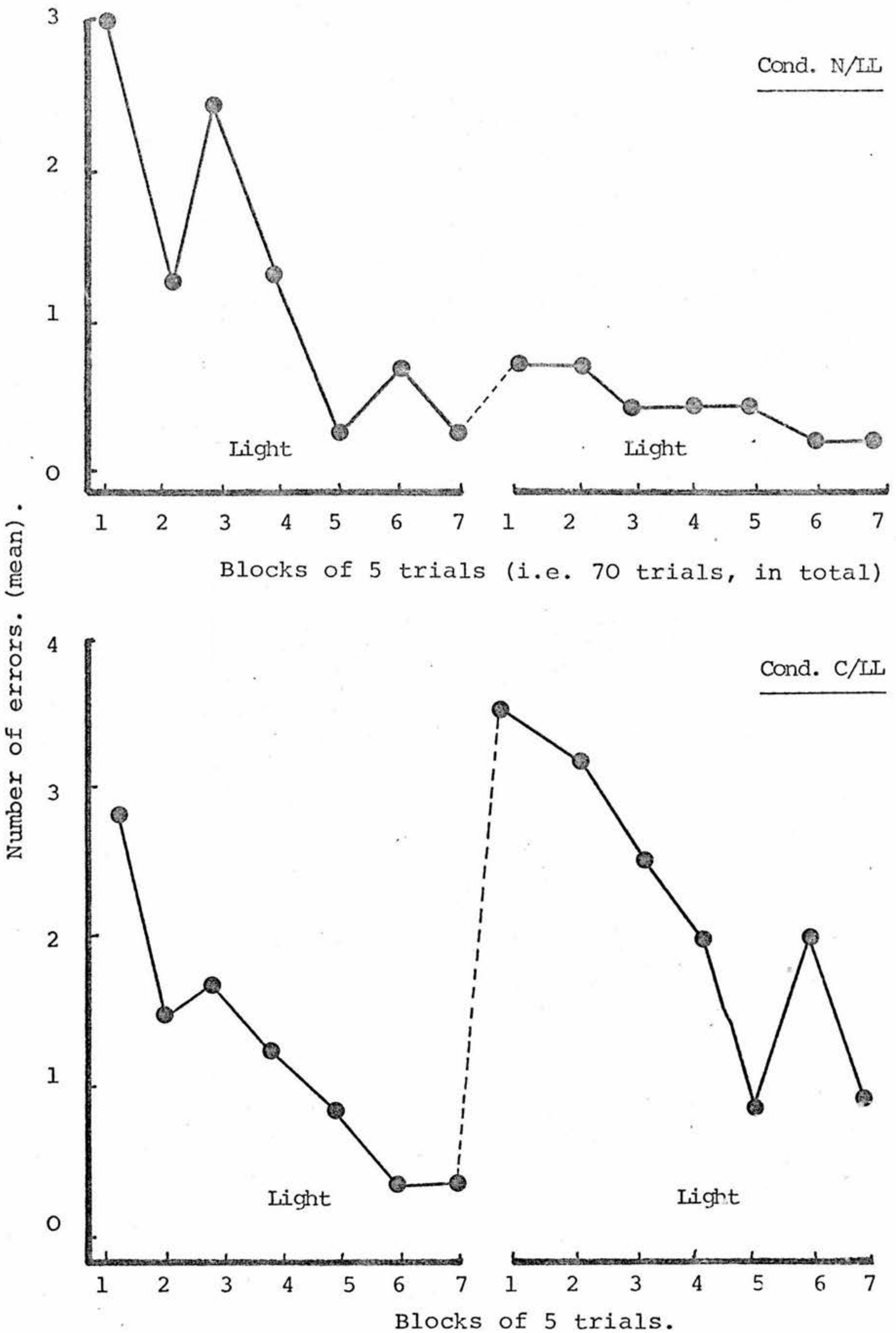


Figure 17 (2). Distribution of errors in Condition LL for the subjects of Group SS' in Experiment 16(2).

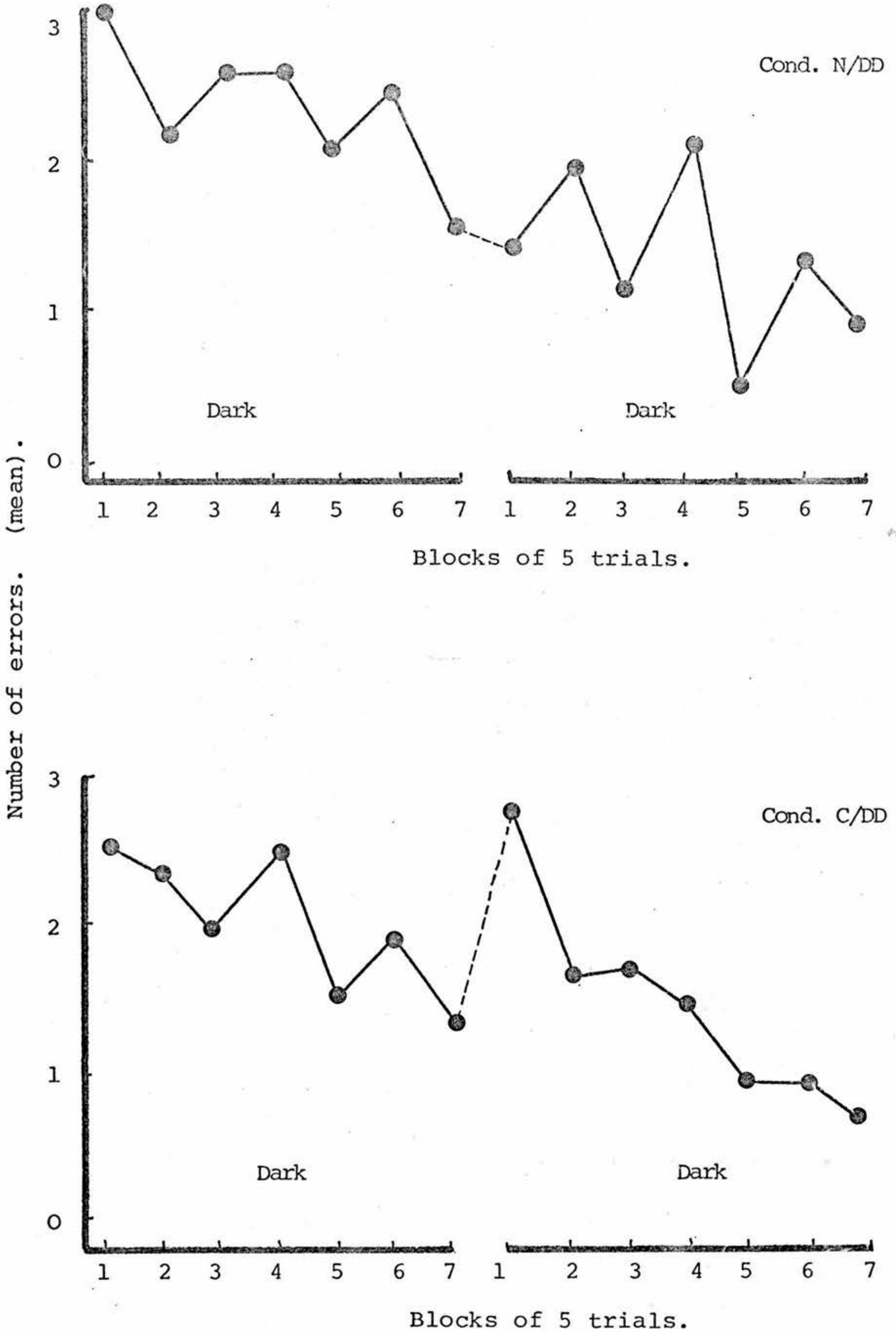


Figure 18 (2). Distribution of errors in Condition DD for the subjects of Group SS' of Experiment 16 (2).

the reward contingency is changed (this is even more evident when the graphs for the Conditions C/DD and N/DD are compared). The four conditions described above have the same lighting conditions in Session One as in Session Two. The following four conditions do not.

Figure 19 (2) displays the graphs for Condition N/DL and Condition C/DL. Both graphs demonstrate the slower learning in Session One in the dark as compared with Session One learning in the light (as described above). However, at the end of Session One, performance is of the order of one error in five responses. Performance in Session Two shows a continuing improvement in Condition N/DL, but a marked discontinuity in the graph representing Condition C/DL shows a regression in the performance when the reward contingency is changed. In each of the changes in the reward contingencies, thus far, the increase in the number of errors at the onset of Session Two appears to be the result of subjects showing stimulus perseveration (i.e. they continue responding to the stimulus that was rewarded during Session One). In fact, in each of the three such conditions dealt with, such perseveration is significant: (Binomial Test carried out on the errors of the first ten trials of Session Two - $p < 0.01$ for a two-tail test). Table 40 (2) displays the errors for each of the four conditions in which reward contingencies were changed, in terms of perseveration or not.

Figure 20 (2) contains the graphs representing the performance under Condition N/LD and Condition C/LD. Performance under Condition C/LD displays all the characteristics that have been previously detailed which are involved with the change in reward contingencies. However, during/

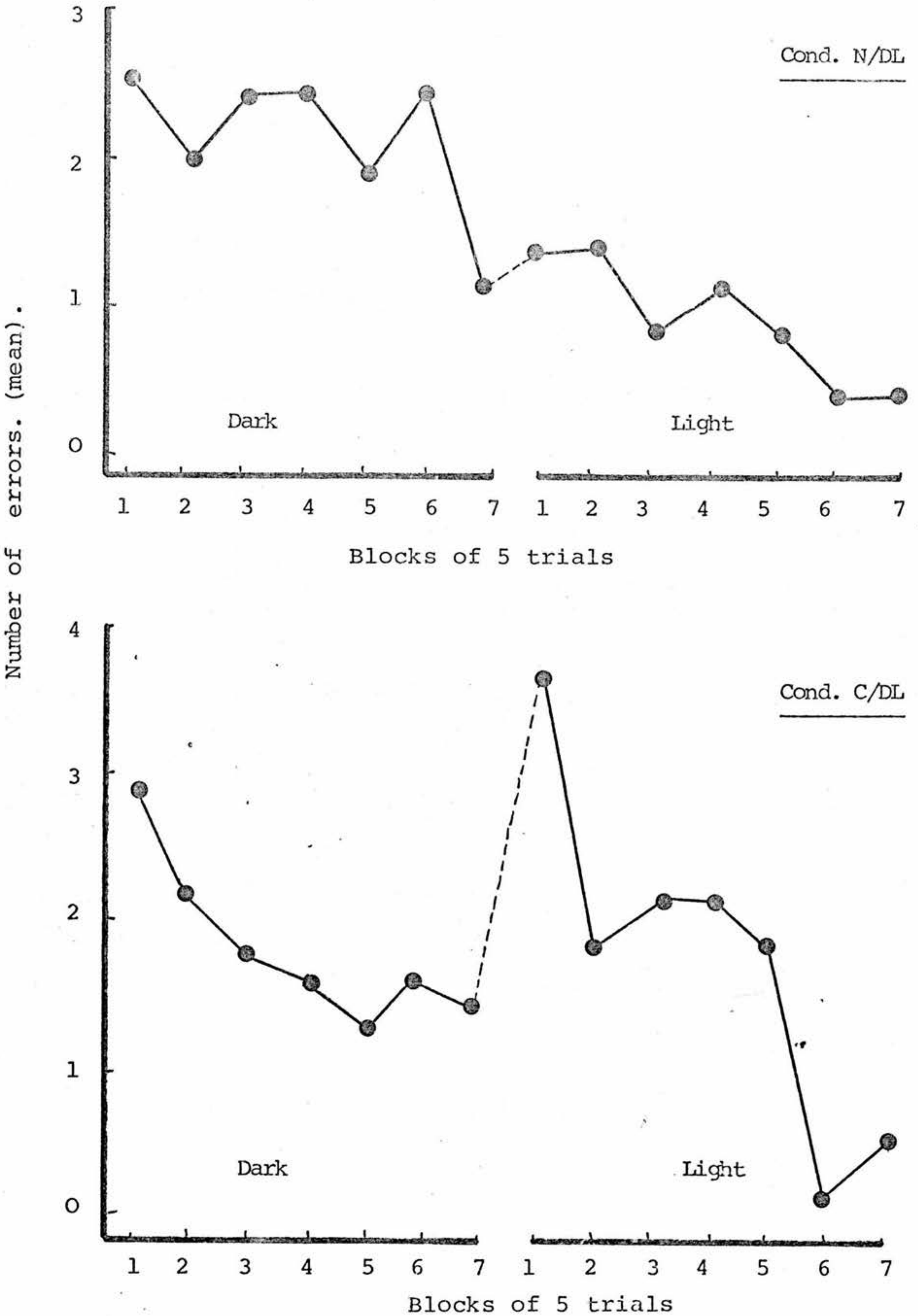


Figure 19 (2). Distribution of errors in Condition DL for the subjects of Group SS' of Experiment 1b(2).

Condition	Errors		p-value
	Perseveration	Non-perseveration	
C/LL	26	8	< 0.01
C/DD	21	5	< 0.01
C/DL	24	7	< 0.01
C/LD	8	13	> 0.20

Table 40 (2). Distribution of errors during the first 10 trials of Session 2, following change in the reward contingency of Experiment 16 (2).

Note: Since 4 comparisons are carried out on the data, the p-values could be artificially inflated. In order to counteract this, the Practical p-values are derived by multiplying the table-values (above) by 4. Thus the first 3 conditions reach significance at the 4% level whilst the remaining condition does not reach anywhere near significance. (See Langley 1968).

Note: That whilst Conditions C/LL, C/DD, C/DL show a significant difference in favour of stimulus perseveration, Condition C/LD is not only not significant, but the difference is in the opposite direction.

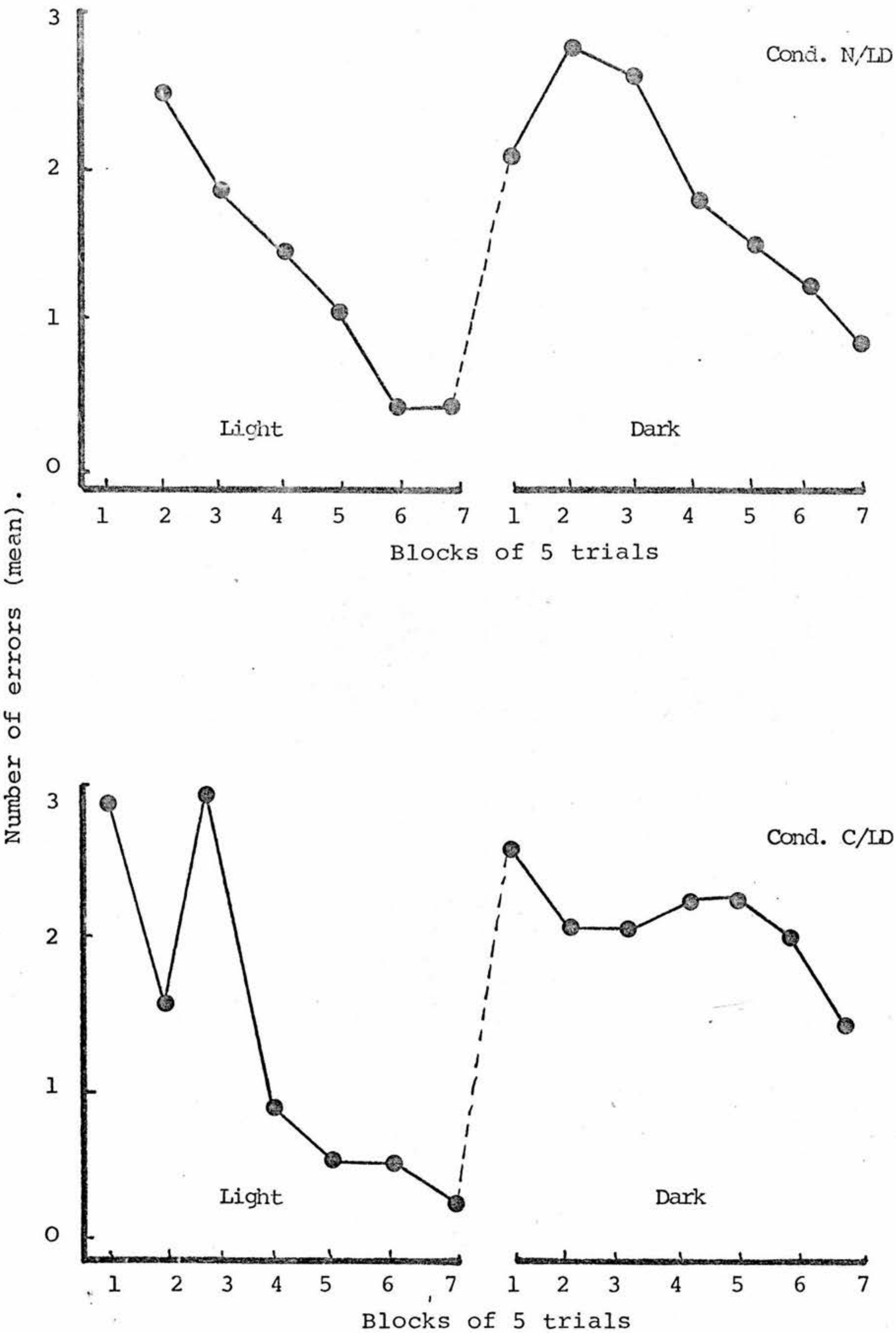


Figure 20 (2). Distribution of errors in Condition LD for the subjects of Group SS' in Experiment 1b (2).

during the acquisition of the new problem that is set for Session Two, the subjects do not show the perseveration that was characteristic of the other three corresponding conditions: (Binomial Test - $p > 0.1$ for a two-tail test). A further departure from the story, thus far, is shown by the performance under Condition N/LD. In the three other conditions in which the reward contingency was retained for Session Two, performance continued to improve - even when the testing conditions were changed from dark to light. However, the graph of Condition N/LD indicates that whatever is learned during Session One is not carried through to Session Two - in fact, the position of the graph representing Session One is such that it resembles those where a change in the discrimination problem has taken place at the inter-session boundary. Table 41 (2) displays this fact in terms of the total number of errors made during the last ten trials of Session One and the first ten trials of Session Two. In the cases of Condition N/LL, N/DD and N/DL, there was no significant difference between the number of errors representing the two sessions - which is what would be expected of adjacent points on a learning curve. In the case of Condition N/DL, there is a significant increase in the number of errors - Table 41 (2) records the results of this analysis.

DISCUSSION

The results of the luminous testing of Experiment 12 (2) indicate that whatever referencing system is used in daylight viewing to identify specific stimulus values did not operate when the problem was transferred to the viewing of self-luminous stimuli in the dark. It was concluded that/

Condition	Session 1	Session 2	p-value
N/LL	4	6	>0.1
N/DD	20	16	>0.1
N/DL	18	14	>0.1
N/LD	4	23	< 0.01

Table 41 (2). A table comparing the total number of errors made during the last 10 trials of Session 1 and the first 10 trials of Session 2 during the No-Change Condition.

Note: For the same reasons as pointed out in the footnote of Table 40 (2), the observed p-values nedd be multiplied by 4 to obtain safe, practical p-values.

that some visual referent was used, which when removed from the testing situation (i.e. when the lights were switched off) abolished the discrimination.

In the testing sessions of the current experiment, a specific stimulus value was required to be chosen from not two, but one stimulus triad. Even with this less exacting problem there was no evidence for transfer of learning from the problem in the light to the problem in the dark.

Indeed, it appears to matter little (in terms of the level of performance) whether the same or different problem is given during the second session'. Clearly, whatever referencing system is being used in the light is not able to operate in the dark. It seems highly likely, therefore, that such a referent is in the (exo- or egocentric) visual environment.

However, learning specific stimulus values in the dark is possible which suggests that some non-visual referent (which the subject carries with him) can come to be used when necessary, but under normal conditions (i.e. in the light) is not utilised. Not only that, but the referencing system that has operated in the dark, and allowed stimulus conservation, is able to operate in the light when a subsequent change in these conditions occurs. These conclusions follow from the results of either the 'non-reversal' conditions, or the 'reversal' conditions of the current experiment.

SUMMARY AND CONCLUSIONS

The experiments reported in Chapter 2 represent a sustained investigation of the relationships involved in the simultaneous discrimination between stimuli that differ in size. The series of experiments was prompted by the theoretical position discussed and adopted in Chapter 1, rather than by the view that discriminations are made on the basis of either Absolute or Relational attributes and that these dichotomous categories are incapable of further subdivision.

In the initial experiment, one group of monkeys was asked to conserve a relationship between stimuli which differed in size from trial to trial, whilst the other group were asked to conserve a specific stimulus value from these same stimuli presented in the same manner. Subsequent extensive testing revealed that the monkeys of Experiment 1 (2) had, indeed, learned to conserve a relationship or a specific stimulus value, as respectively requested. Further, the applicability of this rule of relation between stimuli, that Group R had acquired, was demonstrated to be extensive. Indeed, there was no situation involving the nine stimuli of the basic stimulus pool (arranged in pairs and triads which involved most possible combinations) to which the rule was not successfully and almost immediately transferred. This rule was seen to be applicable in situations where the visual properties of the stimuli were changed, and when the visual context in which they were presented was eliminated. The learning-set experiments described, herein, illustrate that this is, indeed, a rule of relation between the stimuli rather than an acquired response strategy/

strategy of the Win-Stay, Lose-Shift type (Harlow, 1949), since choice behaviour on trial one of each new problem encountered indicated an overall above-chance performance. Not only did the rule of relation between stimuli exhibit strong transitivity between situations of test, but within individual testing situations it was extremely stable and unresponsive to both general and specific sources of interference. Indeed, Group R developed, very much, into a group whose role in the experimental series became one of 'controlling for general procedure'. Although such extensive applicability of rules of relation of the type acquired in Experiment 1 (2) appears to have been implicit in the advocacy of 'relational learning' (or, at least, has never been opposed by this theoretical position) it has never been put to serious test. The experiments of the current chapter indicate that the rule acquired in Experiment 1 (2) stands up to this test. The fact that Group R showed almost immediate transitivity in the case of experiments involving luminous testing (i.e. in which the visual context was eliminated) strongly supports the view that the relationship is, indeed, between the stimuli of the discriminanda - emancipated from contextual cues (i.e. visual referents outwith the discriminanda), confined to the continuum of size, but emancipated from specific stimulus values.

Not only did subsequent testing confirm that Group R had learned a rule of relation of wide applicability between the stimuli of the discriminanda, but it confirmed that Group SS had, indeed, during Experiment 1 (2), acquired the ability to choose a specific stimulus value from the discriminanda - and could apply it, widely, too. However, even the initial discrimination training showed that such retention was more difficult than the retention of relations between stimuli,/

stimuli, and the results of Experiment 2 (2) strongly support this. Further, changing the visual characteristics of the stimuli affect, greatly discrimination performance of the specific stimulus learners, whereas the other subjects were not affected. Prolonged experience of conserving a single specific stimulus value, however, eventually raised the level of performance (even in terms of stability) to that equalling those subjects conserving rules of relation - the learning set performance of Experiment 11 (2) is a case to point.

The group of subjects (Group SSI) who, following initial training on the conservation of a single stimulus value, were subsequently required to concurrently conserve two stimulus values (one per triad), found this task relatively difficult, but eventually reached the stringent criterion required. Initial equivalence testing suggested that this group had required an 'intermediate' rule (since it was possible to solve the discrimination in this way). However, subsequent transfer testing in the learning-set problems of Experiment 11 (2) proved that this could not be the case and showed that they were, in fact, conserving specific stimulus values, as they had done in the initial training of Experiment 1 (2). What is interesting, however, is that given the chance of solving the discrimination in terms of an 'intermediate' rule of relation (consistent across concurrent triads in terms of reward contingencies), they chose to solve the problem in terms of the conservation of two specific stimulus values (inconsistent across concurrent triads in terms of reward contingencies). It is not clear whether this reflects an inherent difficulty in acquiring an 'intermediate' rule, or whether it reflects some 'set' from the initial discrimination training in which specific stimulus value was used./

used. Certainly, there is evidence that in non-humans that the rule 'intermediate' is difficult in relation to 'smallest' or 'largest' (Lashley, 1949) and Warren (personal communication) has also demonstrated the problems non-humans have with the 'intermediate' rule. The terminal performance of Group SSI on the learning-set problems of Experiment 11 (2) was indistinguishable from the other two groups. However, their initial performance was extremely poor, when exposed to the problems comprised of stimuli not very highly discriminable from one another. When confronted with problems which contained more discriminable stimuli, their performance improved to the level of the other two groups and, surprisingly, was maintained when these subjects were returned to the same difficult problems. Rather than interpret this result in terms of the so-called 'easy-to-hard effect', the explanation espoused is that the effects of (proactive) interference between the not very highly discriminable stimuli of the initial presentation of the difficult problems hampers within problem learning - interference which is reduced when the more easily discriminable stimuli of the easy problems are presented, and the specific stimulus learning carried out during the easy problems allows the subjects to 'partition off' various highly discriminable point along the continuum of size, which are subsequently used as 'anchor' points to, in effect, attenuate the interference effects as specific stimulus values need to be conserved when the difficult problems are encountered for the second time. The discrepant findings of Experiment 8 (2), in which Group SSI, apparently, were conserving the 'intermediate' stimulus of the equivalence triads, offer strong support for this posture.

It is concluded, then, that both Group SS and Group SSI are specific stimulus/

stimulus learners - and that whilst their terminal level of performance on the learning-set problems of Experiment 11 (2) is of a similar level to that of Group R, this should not detract from the results of earlier experiments demonstrating distinct inferiority in terms of susceptibility to external interference.

The performance of Group SSI and Group SS (in relation to that of Group R) under conditions of luminous testing is of fundamental importance to the theoretical position promoted by this thesis. Whilst the performance of Group R was scarcely affected by the removal of the visual context during transfer testing, the choice behaviour of Group SS and Group SSI was completely eliminated. This gives rise to two points of support. One, the logical position taken in Chapter 1 with respect to the necessity for (visual) referents in the identification of specific stimulus values claims strong support from this result (Group SS) and Two, the view that Group SSI is closely allied to Group SS in its mode of learning (i.e. specific stimulus learning) is, further, supported. The success of Group R in the same conditions of luminous testing, rules out the possibility that the change in conditions was disruptive in terms of general procedure. More extensive testing, however, did show that both Group SS and Group SSI could, eventually, discriminate under these conditions of training, but using problems involving one rather than two triads. This suggests that, not only is there a visual referencing system used in the construction of specific stimulus values (which was eliminated in the first exposure to luminous testing), but that a second, non-visual, referencing system (hitherto unused) can become effective in the absence of the first. What is, perhaps, surprising is that this second non-visual system/

system appears to have been inoperative in the normal-lighting sessions, since there seems to be no evidence of its providing transfer from the normal-lighting to the luminous sessions. The final experiment of the series in the current chapter examined this further, and the results strongly support the position requiring the operation of two referencing systems. That is, whilst the identification of specific stimulus values in normal-lighting sessions is eliminated in subsequent luminous sessions (confirming the results, thus far, but using repeated measures), the converse is not the case - i.e. identification of specific stimulus values acquired in luminous testing do transfer to normal-lighting conditions. Thus learning acquired with the non-visual referencing system is not lost when conditions are changed, but the learning acquired with the visual referencing system is lost when condition change. It remains to be seen whether subjects eventually learn to utilise the non-visual system in the presence of an operating visual referencing system - for example, in a paradigm involving alternate changes between luminous and normal-light testing sessions in a manner analogous to reversal learning paradigms - or whether the operation of one system prevents the operation of the other.

The experiments reported in Chapter 2, thus serve to identify three types of relationships which are used by squirrel monkeys in discriminating between stimuli that differ in size.

1. Relationships between the stimuli of the discriminanda and which are emancipated from contextual cues.

2. Relationships between the individual stimuli of the discriminanda and/

and referents in the visual environment - either visual parts of the body of the subject or objects in the visual world, not part of the subject's body. In effects, such referents would generally be of an invariant nature during successful discrimination.

3. Relationships between individual stimuli and referents which are not part of the visual environment - some aspect of 'body sense' which remain invariant during successful discrimination (for example, 'so big that I need look up to it, so small that I need look down to it) - and which appear to operate when visual referents are absent.

The problem of which referent comes to be used in discrimination training is a complex one - particularly with respect to specific stimulus learning. The choice of species ought to be critical since (as Seligman and Hager, 1971 have detailed) different species, as a result of the evolutionary pressures experienced, will be more prepared to make some comparisons between specific stimulus and referent and less prepared to make others. For this reason, the choice of apparatus in conjunction with the choice of different species, is also critical (either in terms of its construction or in terms of the task required of the subject) since particular pieces of apparatus will favour, strongly, some stimulus/referent comparison whilst making others extremely difficult. Thus, to say that a particular species is incapable of learning in what has come to be called the 'absolute' or 'relational' way or, indeed, that some species are better 'absolute' learners than 'relational' learners or vice versa, is to say a little about the species, but more about the way in which the subject has been/

been asked the question. For example, the subject could well be a superb 'relational' learner, but the choice of referents offered to him in terms of the construction of the apparatus could be such that 'absolute' learning does occur; and the converse applies. The experiment to which reference was made in Experiment 1 (2) is a case to point. In collaboration with B.O. McGonigle and R. Osborne, rats were trained on exactly the same paradigm and with exactly the same stimuli as the squirrel monkeys of Experiment 1 (2) - except for the fact that a Jumping Stand was used. 'Relational' learning was demonstrated, but 'absolute' learning was not - even after a vast number of trials. However, when the conditions of the experiment were changed such that the subjects needed to go through the size stimuli in order to gain access to food, then 'absolute' learning was achieved. Indeed, in the experiments of Meyer (1964) discussed in relation to the learning in Experiment 1 (2), a Grice box was used in which the size stimuli needed to be judged had doors at their centre through which subjects needed to pass - and in this experiment, 'absolute' learning was achieved, as well as 'relational'. Much of the contrary evidence produced within the so-called Absolute-Relational controversy is the product of such variant procedures.

The current series of experiments has enabled two types of referencing systems involved in the discrimination of specific size values to be identified. The specific referents used, however, need to be the subject of further study.

C H A P T E R 3

RULES OF RELATION INVOLVED IN DISCRIMINATING BETWEEN STIMULI THAT DIFFER IN BRIGHTNESS.

The experiments reported in Chapter 2 were concerned with discriminations between objects that differed in 'size'. Conclusions were drawn with respect to the different relationships involved in discriminating between such objects - although it was never established what constituted 'size' (indeed, this was not the designed purpose of the experimental series). The experiments reported in Chapter 3 are concerned with discriminations between stimuli which differ in the attribute of brightness. Analogous questions are asked of monkeys in their commerce with these stimuli as were asked of monkeys in their commerce with the size objects of the previous chapter.

It is highly improbable that the same referencing systems that were used in the discriminations of the previous chapter could be used in brightness discriminations. Rather than having to discriminate between whole objects which differ in size (a complex commodity), the monkeys in the current chapter need to discriminate between stimuli which differ with respect to a relatively simple attribute. However, it is difficult to see how any egocentric referencing system could be involved in such discriminations, for example. The current series of experiments, therefore, serve to determine what referencing systems are involved in discriminations which are trained using the same paradigm as in Experiment 1 (2) of the previous chapter.

E X P E R I M E N T 1 (3)

INTRODUCTION

The current experiment is designed to determine whether or not so-called absolute and relational learning can be carried out using the dimension of brightness, in a manner similar to that of Experiment 1 (2). The relative stabilities of the two types of learning is, thus, investigated. Since the subjects used in the current experimental series are the same as those from the previous experimental series, the further purpose of the current experiment is to determine whether there is any differential transfer from the previous learning to the current learning. Should differential transfer be detected, then some indication as to the reference systems used in brightness discriminations ought to emerge. Should no such transfer be detected, then the remaining experiments will serve to determine the nature of the relationships involved in discriminating amongst different brightnesses.

METHOD

Subjects

The subjects used in Experiment 1 (3) had served in the bulk of the experiments reported in Chapter 2. Their conditions of maintenance were as described before. The series of experiments reported in the current chapter were conducted immediately following completion of Experiment/

Experiment 11 (2) of the previous chapter.

Apparatus

The same W.G.T.A. as was used for the size discrimination series was used for the current experiments. The conditions of lighting were changed, however - in the current experiments, baffles were introduced to prevent the specular component of light from being reflected from the stimuli towards the subjects. A two-stimulus presentation tray painted matt white replaced those used in the previous experiments. In later experiments in the current series, the specification of this tray was changed - and will be detailed in the appropriate section.

Stimuli

A series of nine ceramic tiles differing in reflectance values made up the stimulus pool. They were of dimensions 2" x 2" and $\frac{1}{8}$" thick, and were mounted centrally on 3" x 3" wooden plaques painted matt white and the same surface texture as the stimulus tray. The plaques were modified in later experiments, which will be described later. Table 1 (3) records the reflectance values for these stimuli. Note that the higher the stimulus number, the darker the stimulus tile.

Experiment 1 (3) uses Stimulus two, four and six, presented in two pairs in an analogous way to the initial discrimination of the size series - i.e. Stimulus two and four and Stimulus four and six.

Procedure and Design

The subjects were allocated to one of three groups as follows:

Group/

Stimulus Number.	1	2	3	4	5	6	7	8	9
Munsell Value *	9	8	7	6	5	4	3	2	1
Description.	white								black

Table 1(3). Equivalent brightness values of the stimuli used in the experiments of Chapter 3. Munsell values.*

Note: The ceramic tiles have *permanent* brightness characteristics.

* Based on A.H. Munsell (1915), 'Atlas of the Munsell Color System'. (See D. Nickerson, J. Opt. Soc. Amer., 1940, 30, page 575. and W.D. Wright, 'The Measurement of Colour' London: Hilgar and Watts, 1964-3rd edition.)

The ceramic tiles were a gift from Professor W.D. Wright to Dr. B.O. McGonigle. The further optical charateristics of the tiles can be obtained from the standardization procedure carried out at the Imperial College of Science and Technology, London. The Munsell values have been used in their description since they are universally known.

Group R. (n=3). Those subjects who comprised Group R of the experiments of Chapter 2 - i.e. had responses to the largest stimulus rewarded. In the current experiment they had responses to the darkest stimulus rewarded.

Group SS. (n=3). Those subjects who comprised Group SS (as defined in Experiment 11-2) of the size series of Chapter 2 - i.e. had responses to a specific stimulus value rewarded (Stimulus C). In the current experiment they had responses to specific brightness rewarded - Stimulus four.

Group SSI (n=3) Those subjects who comprised Group SSI of the size series experiments (as defined in Experiment 11-2) - i.e. had responses to the 'intermediate' stimulus rewarded. In the current experiment, they had responses rewarded in a manner identical to that of Group R, above, in that the responses to the darkest stimuli were rewarded.

The general procedure of testing was identical to that of Experiment 1 (2) of the previous chapter. Brightness stimulus pairs two and four, and four and six were equivalent to size stimulus pairs B and C, and C and D.

RESULTS

Table 2 (3) displays the performance of the three groups up to the 18/20 criterion of acquisition. A simple analysis of variance on errors/

Group	Subject	Trials	Errors		
			Light Pair	Dark Pair	Total
SSI	1	77	12	14	26
	2	72	19	16	35
	3	139	25	33	58
	Mean	46	19	21	40
SS	4	143	38	26	64
	5	186	34	27	61
	6	152	32	35	67
	Mean	160	35	29	64
R	7	91	19	27	46
	8	44	15	13	28
	9	40	11	11	22
	Mean	58	15	17	32

Table 2 (3). The performance of the 3 groups of Experiment 1 (3) up to the 18/20 criterion.

errors indicated that there was a group effect. Sheffe comparisons showed that the difference was located between Group R and Group SS, and between Groups R and SSI (combined) and Group SS. This was the case for both errors and trials to criterion (Errors - $F = 7$; $df = 2,6$; $p < 0.025$, see Table 3-3 for Source Table. Trials - $F = 11.8$; $df = 2,6$; $p < 0.01$, see Table 4-2 for Source Table). Sheffe comparisons were significant at at least the 2.5% level.

Over the first thirty trials, only one subject showed a significant preference for either the lighter or darker stimuli - Subject (of Group R at the 5% level).

No significant differences were obtained between the groups up to the more stringent criterion that was required: the same more stringent criterion as in Experiment 1 (2) of the size series.

DISCUSSION

Clearly, the groups have learned the discrimination and, thus, specific stimulus values of brightness and relationships between differing brightness values can be conserved in a manner analogous to that involving the size continuum. The results of Experiment 1 (3) are consistent with those of Experiment 1 (2) in that those subjects (as a group) who were asked to conserve a specific stimulus value took longer to reach the same level of performance as those subjects who were asked to conserve a specific stimulus value took longer to reach the same level of performance as those subjects who were asked to conserve a relationship between stimuli. It appears unlikely that this effect is due to differential transfer from the size discrimination series/

Source	SS	df	MS	F	p
Total	2549.56	8	-	-	-
Between	1674.89	2	837.45	7.66	0.025
Within	874.67	6	109.33	-	-

Table 3(3). Source Table of the variance contributed by the factors of Experiment 1 (3) - Errors.

Source	SS	df	MS	F	p
Total	21384.9	8	-	-	-
Between	15961.6	2	7980.77	11.77	0.01
Within	5423.33	6	677.98	-	-

Table 4(3). Source Table of the variance contributed by the factors of Experiment 1 (3) - Trials.

series since no difference was detected between Group R and Group SSI (who, in the current experiment, experienced the same reward contingencies). The fact that no difference was detected between Group SS and Group SSI, also supports this view - since, in Chapter 2, it was demonstrated that Group SSI was specific stimulus learning group, just as was Group SS, and in the current experiment Group SS and Group SSI (of the same origin in terms of the size series) have different reward contingencies.

Thus, the results of the current experiment are consistent with the position proposed and discussed in the previous chapters - that it ought to be more difficult to remember specific stimulus values rather than relationships between stimuli, and the theoretical position of Wertheimer (1959 - hitherto, untested) supported. During post-criterion stabilizing trials, however, all differences between the groups disappeared (unlike the results of Experiment 1-2). However, this is interpreted as representing the test-sophistication of the subjects (i.e. reaching a stable level of performance earlier than in corresponding experiment of the size series), rather than any basic difference between the size and brightness discriminations.

EXPERIMENT 2 (3)

INTRODUCTION

The previous experiment demonstrated the relative difficulty that is experienced in the retention of specific stimulus values as compared with the retention of relationships between stimuli. The current experiment is equivalent to Experiment 2 (2) of the size discrimination series in which subjects are subjected to a specific source of external interference prior to being required to discriminate.

METHOD

Subjects

The nine subjects of the previous experiment took part in Experiment 2 (3), and were retained in their original groups.

Apparatus

This was identical to the set-up of the previous experiment.

Stimuli

In addition to the training stimuli of the previous experiment, Stimulus one and eight were added to the stimulus pool.

Procedure and Design

The procedure and design of the current experiment was almost identical to that of the corresponding experiment of the size series -

Experiment/

Experiment 2 (2). Pre-exposure configurations consisted of either Stimulus one or Stimulus eight presented in an identical manner to that in Experiment 2 (2). The testing trials following pre-exposure with Stimulus one employed Pair 2-4; whilst those following pre-exposure with Stimulus eight employed 4-6. Note that the pre-exposure stimuli have no history of their being rewarded.

RESULTS

The pre-exposure trials had negligible effect upon the subsequent pre-exposure test trials. In fact, subjects of Group SSI and Group R showed no disruption, whatsoever - whilst subjects of Group SS showed a total of two disruptions (out of a total of forty-eight trials). Clearly, there is no significant effect, and it was not thought necessary to include the results' table.

The above experiment was repeated using pairs of pre-exposure stimuli rather than single pre-exposure stimuli. For example, a pair of identical (Stimulus one) stimuli were presented in place of a single (Stimulus one) stimulus - one member of the pair over one foodwell, and the other member over the other.

No increase in disruptive effects was observed, from the position described above, and for this reason, the results' table has not been included.

DISCUSSION

The results of Experiment 2 (3) were totally different from those of the/

the equivalent experiment of the size series, in that the specific source of external interference which, in the latter case produced significant disruption of choice behaviour, had negligible effect. In the initial trials, the pre-exposure stimuli were placed in the centre of the stimulus tray and it is, at least, possible that in such a position, the subjects' attention was distracted from them by the visible nature of the (uncovered) foodwells which, hitherto, had been very closely associated with reward. Thus, the potential influence of the pre-exposure stimuli could have been very much reduced. In the later trials, however, the pre-exposure stimuli were presented in pairs and placed over the foodwells, and in such a position ought to be much more powerful 'attention getters', permitting their disruptive effects to be more meaningfully measured. However, even with this procedure, the disruptive effects of the pre-exposure stimuli were minimal - and, as such, represent a marked deviation from the corresponding experiment of the size series.

There are several possible explanations of this discrepant behaviour. Even with the precautions detailed above, it may be the case that the subjects are so experienced with different stimuli appearing on the tray that novel ones no longer capture attention for the length of time necessary to interfere with retention. However, it may be the case that in Experiment 2 (2) different <u>objects</u> were the subject of the discrimination, whereas in the current experiment it is object <u>attributes</u>. The results of the current experiment do not necessarily indicate, therefore, that the conservation of specific stimulus values by Group SS is qualitatively different from the conservation of specific size values.

E X P E R I M E N T 3 (3)

INTRODUCTION

The results of Experiment 1 (3) strongly support the view that both so-called absolure and relational learning has taken place - in that they are consistent with the equivalent experiment of the size discrimination series. (However, the results of the previous experiment are not directly in concord with this view). The current experiment gives the three groups the opportunity to apply whatever they have acquired in their brightness discrimination training to novel stimulus pairs - and the experiment is equivalent to Experiment 3 (2) of the size discrimination series.

METHOD

Subjects

The same nine subjects as took part in the previous experiment took part in Experiment 3 (3). They were kept in their original groups.

Apparatus and Stimuli

These were the same as in Experiment 2 (3).

Procedure and Design

This was the same as the corresponding experiment of the size series - Experiment 3 (2). The exception being that the three pairs of size stimuli used in the non-differentially rewarded equivalence testing were/

were replaced by brightness pairs: Pair 1-2, Pair 2-6 and Pair 6-8.

RESULTS

The results of the equivalence testing is displayed in Table 5 (3). Significant preferences were shown, in equivalence testing with Pair 2-6, by all groups (Binomial Test on the totals for each group derived from Table 5 (3) - $p < 0.002$ for a two-tail test in all cases). No significant choice bias, however, was shown by any group with Pair 6-8 ($p > 0.3$ for a two-tail test) and only Group SS showed a significant choice bias with Pair 1-2 ($p < 0.002$ for a two-tail test).

DISCUSSION

The results of the current experiment are not as conclusive as those of the equivalent experiment from the size series. The choice behaviour of Group R and Group SSI with Pair 2-6 is consistent with their having acquired a rule of relation, but the fact that Group SS also show a significant bias in the same direction with this pair does not allow such a conclusion to be firmly drawn. Especially as Group SSI and Group R do give much evidence of 'transposition' behaviour with the other stimulus pairs. The performance of Group SS, however, with Pair 1-2 is supportive of their having learned to conserve a specific stimulus value, but their performance with Pair 6-8 is not.

There are explanations for these inconclusive results. The fact that Group SS displayed a significant choice bias with Pair 2-6 (both stimuli of which have been previously correlated with non-reward) when in the case of Experiment 3 (2) they did not, suggests that Stimulus six may, indeed, be nearer to Stimulus four (the positive stimulus) than/

Group	Subject	Equivalence Testing Pairs					
		Pair 1-2		Pair 2-6		Pair 6-8	
		1	2	2	6	6	8
SSI	1	5	5	1	9	4	6
	2	3	7	0	10	6	4
	3	3	7	0	10	5	5
	Total	11	19	1	29	15	15
SS	4	3	7	1	9	6	4
	5	2	8	1	9	6	4
	6	0	10	3	7	5	5
	Total	5	25	5	25	15	15
R	7	4	6	2	8	6	4
	8	6	4	0	10	5	5
	9	4	6	1	9	5	5
	Total	14	16	3	27	16	14

Table 5 (3). The distribution of responses during the equivalence testing of the 3 groups of Experiment 3 (3).

than is Stimulus two. Further, in the remaining cases of equivalence testing, the choice bias is never opposed to the bias which would be expected if discrimination behaviour had been learned in the same way as in the previous chapter - there is, simply, no significant choice bias and it is thus ambiguous. It is as though the equivalence testing stimuli were not judged as representing the original discrimination. Lashley (1938) has already suggested that the dimension of brightness in non-humans has unpredictable characteristics at its extreme values. The current experiment could be a case to point.

However, as was suggested in the experiments of Chapter 2 (and, indeed, will feature in the experiments of the next chapter), non-differentially rewarded equivalence tests are notoriously insensitive as measures of transfer, and as a consequence indications of chance responding should be treated with caution. The following experiment serves to determine whether, amongst other things, such lack of choice bias where it was predicted is not the result of an insensitive test procedure.

EXPERIMENT 4 (3)

INTRODUCTION

The relative learning measures of Experiment 1 (3) are consistent with the view that Group R and Group SSI have acquired a relationship between stimuli, whereas Group SS has conserved the choice of a particular stimulus value. The previous two experiments, however, have produced results which are ambiguous, in this respect.

The current experiment is designed to determine, therefore, whether or not Group R and Group SSI have acquired a rule of relation between brightness stimuli. The stimulus pairs of the previous experiment are used, but in a design involving prolonged testing and differential reward. However, to detect whether subjects of these two groups have acquired a general rule of relation (which they can apply in the problems met in the current experiment, should this be the case) or whether they have developed a general response strategy of the Win-Stay, Lose-Shift type, some subjects of the two groups will be inconsistent with the general rule 'darker'. Thus, Group R and SSI will be given the opportunity to apply whatever they have learned as the basis of their discrimination, over a wider series of stimulus pairs than encountered in the original brightness discrimination training. To these ends, the current experiment is equivalent to Experiment 11 (2) of the size discrimination series.

Group SS feature in Experiment 4 (3) in the same way as they did in Experiment/

Experiment 11 (2) - their ability to conserve a specific stimulus value (brightness) from many more stimulus pairs is assessed.

METHOD

Subjects

The nine subjects that took part in the previous experiment took part in Experiment 4 (3). For the current experiment, Group SS remained intact - but Group R and Group SSI were combined to form a new group. This latter group was to be subdivided for the current experiment, the details of this division are given below.

Apparatus and Stimuli

The same W.G.T.A. as was used in earlier experiments was used in Experiment 4 (3), in conjunction with the nine stimuli detailed in Table 1 (3).

Procedure and Design

A fixed-trial learning-set design was employed, in which six problems were given over six consecutive days at the rate of one problem per day. The problems consisted of seventy differentially-rewarded trials with a stimulus pair. One stimulus pair comprised one problem. The general testing procedure was equivalent to that used for Experiment 11 (2) of the size discrimination series (except for the fact that two-stimulus presentation was used.

Each subject of Group SS received the five following problems once, and one of these problems twice: Pair 1-4, 3-4, 4-5, 4-7 and 4-8. Thus,/

Thus, each subject of Group SS received a series of six problems - each subject receiving the problems in a different order. Subjects of Group SS were required to conserve a specific stimulus value in their choice (Stimulus 4).

The combined Group R and SSI were combined and the subjects of this new group received the following three problems twice: Pair 1-2, 2-6 and 6-8. The order of presentation of the six problems was counter-balanced as far as was possible in the usual way. One half of this new group was to receive the same reward contingencies as had been experienced thus far in the brightness series - i.e. responses to the darker stimulus were rewarded. This group was called Group C (= consistent reward). The group was made up of one subject from Group SSI and two from Group R. The other half of the new group was made up of the remaining three subjects. This group, Group I (= inconsistent) had responses to the darker stimuli rewarded on one problem, then the contingencies were reversed for the following problem, and so on. One subject of Group I began the series of problems with the lighter stimulus rewarded, and the other two began with the darker stimulus rewarded. Both of these two groups were matched for performance thus far, as far as possible.

RESULTS

Table 6 (3) records the performance of each of the groups on the ordinal problems of Experiment 4 (3). Figure 1 (3) displays this graphically. Visual inspection of Figure 1 (3) indicates that the performance of Group SS on the six learning-set problems is good, and similar/

Group	Ordinal Problem Number					
	1	2	3	4	5	6
SS	84	89	90	91	92	82
C	94	93	97	97	91	94
I	43	70	63	67	72	72

Table 6(3). The performance of the 3 groups of Experiment 4(3) on the discrimination problems of the learning-set.

Note: The measure is total percentage correct responses per group. Figure 1(3) displays this information, graphically.

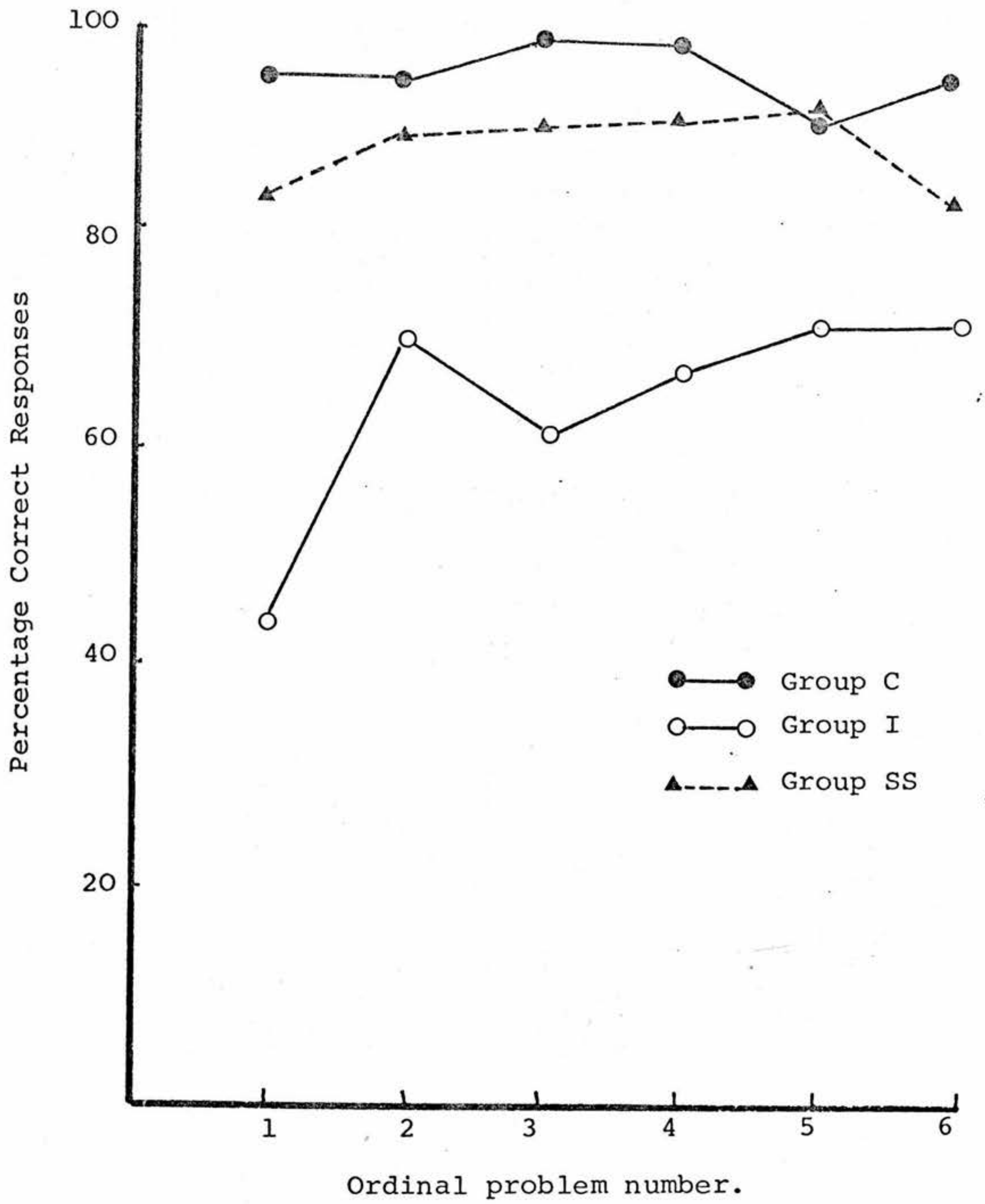


Figure 1(3). The performance of the 3 groups of Experiment 4(3) on the problems of the learning-set.

similar to that of Group C which is also good. The performance of Group I, however, is poor and in terms of percentage error per problem hardly deviates from chance behaviour. A non-parametric analysis of variance was used to assess these differences (the variance of both Group SS and Group C was much different from that of Group I) and a significant difference between the groups was shown to exist (Friedman's Analysis of Variance - Chi = 10.33; df = 2; $p < 0.01$). The location of the difference was between Group C and Group I ($F = 4.491$; $n = 6$ - See Table 5 (2) for formula used to derive F-value and for the reference). A non-parametric analysis of variance using related measures would not be able to assess the 'middle' of three groups in terms of either of the other two (except in determining that they are not significantly different from the 'middle' group). However, the main purpose of the current analysis is to compare Group I and C.

Group C made significantly more correct responses on trial one of the learning-set problems than chance responding would produce (Binomial Test - $p < 0.05$ for a two-tail test) - fourteen correct responses and four incorrect responses. However, three of these incorrect responses were confined to the first two problems. Group I responded at chance on these same trials - eleven correct responses, and seven incorrect ones. Group SS also responded at chance on trial one (ten incorrect and eight correct responses).

DISCUSSION

The results of the current experiment are consistent with the view that Group C have, indeed, acquired a rule of relation between brightness values - the overall performance and their performance on trial/

trial one of the learning-set problems support this. Group I, on the other hand, show little evidence of positive transfer from the original discrimination and offer no support for the position that they acquired the original discrimination using a general response strategy. The performance of Group C, however, in the current experiment produces some surprises, in that they showed little transposition behaviour in the equivalence testing of the previous experiment and yet their trial one behaviour in the current experiment suggests that they ought to have. There are two possible (related) explanations. The relative insensitivity of non-differentially rewarded equivalence tests is well known (Warren and McGonigle 1968, and several instances in the experimental chapters of the current report) - indeed, it was this fact that prompted the design of the current experiment. Also, increased experience with differentially rewarded trials using stimuli that are from the 'extreme' ends of the continuum in a testing situation similar to that used in the original discrimination training ought to increase the subjects' preparedness to relate more novel values of that continuum. It appears that the subjects of Group C acquire this ability very quickly.

The performance of Group SS does show that the ability to identify specific stimulus values when presented with a range of alternatives is good. However, their trial one performance does show that this ability is not as good as that of Group C. This result is taken as supporting the view that the relative stability of the two learning procedures is different - and is consistent with the results of Experiment 1 (3) and the results from the previous chapter.

Group/

Group I were returned to the learning-set procedure and treated in exactly the same way as were Group C, for one exposure to the three different problems. Thus, when they completed this procedure, they were reliably responding to 'darker' as were Group C.

E X P E R I M E N T 5 (3)

INTRODUCTION

The previous experiments strongly support the view that specific brightness values can be conserved and that relationships between differing brightness values can be conserved along the continuum. These results are consistent with what was discovered with respect to the continuum of size in the previous chapter. Further, the results support the position that the retention of specific brightness values is more labile than the retention of relationships between brightness values (although the extent to which this has been shown in the current chapter is not as great as in the previous one), and in this respect is also consistent with the previous chapter's findings.

The position was developed in Chapter 1 and Chapter 2 that the retention of absolute stimulus values without recourse to some referent was a logical absurdity. In the previous chapter, two referencing systems were identified as being involved in the recognizing of specific size values. Experiment 5 (3) and the remaining experiments of the current chapter serve as an attempt to recognize what referents may be used the identification of brightness. The current experiment examines the role played by the plaques on which the ceramic stimulus tiles are positioned. The brightness value of the plaques has been invariant throughout the brightness discrimination series, and as such is a contender for the role of referent.

METHOD/

METHOD

Subjects

The nine subjects that took part in the previous experiment took part in the current experiment. They retained the group identity of the previous experiment.

Apparatus and Stimuli

The stimuli used consisted of the training stimuli of Experiment 1 (3). The same W.G.T.A. was used as was used in previous experiments with the same matt white tray. However, for specific tests, the plaques on which the ceramic stimulus tiles were mounted were changed from the matt white brightness to a brightness which matched the ceramic tile of Stimulus four.

Procedure and Design

In order to begin equivalence testing in the current experiment, subjects had to make no more than one error on the twelve training trials which were the beginning of each day's testing. These were identical to the training trials of Experiment 1 (3). Following completion of this requirement, twenty-three trials were given of which twelve were non-differentially rewarded equivalence trials using stimuli with the modified plaques and the remaining eleven trials were differentially rewarded training trials with stimuli having the standard matt white plaque. The stimulus pairs used, throughout, were Pair 2-4 and 4-6. Testing was carried out for two consecutive days.

RESULTS

There was no significant disruption of choice behaviour for any subject of any of the three groups. In fact only Subject 3 (one disruption on Pair 4-6) and Subject 7 (one disruption on Pair 2-4) showed any effect - out of twenty-four equivalence trials. Only one disruption was seen during the interpolated training trials (Subject 7). It was not felt necessary to tabulate the results.

DISCUSSION

It appears that the stimulus plaques have no role in the recognition of brightness. At first, this may seem to be inconsistent with the results of the corresponding size experiments. However, the presence of the relatively large stimulus tray may be the explanation. The visible borders of the plaques were small in relation to the tray, and the tray was also an invariant feature of the training procedure as was the stimulus plaque. Not only this, but it may be the case that the plaques are being used (along with the stimulus tray) but that the continued presence of the stimulus tray during the equivalence testing is sufficient to provide an unchanged reference.

The following experiment serves to determine the role of the stimulus tray, as well as the plaques, in the choice behaviour.

EXPERIMENT 6 (3)

INTRODUCTION

The previous experiment demonstrated that the effect of the stimulus plaque upon the choice behaviour of the subjects of the three groups was negligible, in the presence of an unchanged stimulus tray. The present experiment determines the combined role of the plaques and the stimulus tray, in choice behaviour.

METHOD

Subjects

As in the previous experiment.

Apparatus and Stimuli

As in the previous experiment, except for the fact that a different stimulus tray was introduced on selected trials (along with the modified plaques detailed in the previous experiment). The modified stimulus tray was identical to the usual matt white tray, in structure, but was painted to the same brightness as Stimulus four.

Procedure and Design

This was identical to the previous experiment, save that upon equivalence trials, both the stimulus plaque and the stimulus tray were changed to the modified version. Testing was carried out for two consecutive days.

RESULTS/

RESULTS

Table 7 (3) records the distribution in choices during the equivalence testing for the three groups taking part in Experiment 6 (3). Clearly, the performance of Group I and Group C was scarcely affected by the change in tray and plaques. The performance of Group SS, however, was affected to a marked degree. A large difference in variances does not permit the use of parametric analysis to be used on the current data. However, a Kruskal and Wallis Test is permissible, and a significant difference is found between the three groups in terms of the number of disruptions produced with both Pair 4-6 (Chi-squared = 5.6; p = 0.05) and Pair 2-4 (the same values). Subsequent paired comparisons indicate that this difference is located between Group SS and Group I for Pair 4-6 and between Group SS and Group C for Pair 2-4. (See Langley 1968, page 219-221 for details of method). Thus, the overall picture is that Group SS are disrupted by the change in testing conditions, but not Group C and I. The fact that the non-parametric analysis of variance has not detected group differences which are obvious from visual inspection of Table 7 (3), is a feature of this type of analysis when three groups are being compared (this feature was met in the analysis of the learning-set data in a previous experiment of the current chapter).

Inspection of Table 7 (3) shows that the disruptive effects were confined to the equivalence tests, since Group SS did not show any appreciable disruption during the interpolated training trials.

DISCUSSION

It/

Group	Subjects	Equivalence Shifts Light Pair	Dark Pair	Interpolated training errors
C	3	1	0	0
	7	0	0	0
	8	0	1	1
	Total	1	1	1
I	1	1	0	0
	2	1	0	0
	9	1	0	0
	Total	3	0	0
SS	4	2	12	1
	5	4	8	1
	6	4	7	0
	Total	9	27	2

Table 7(3). The distribution of responses during the equivalence testing of Experiment 6(3) and the accompanying errors during the interpolated training trials.

Note: The maximum score for any subject under either of the equivalence pairs is 12. The maximum number of error during the interpolated training trials is 11

It appears that the brightness of the stimulus tray is of prime importance in the identification of specific stimulus values. Thus, Group SS were affected by the change in testing conditions. Group I and Group C were not affected, and this supports the view that they have learned a rule of relation between stimuli which differ in brightness. There is also further support for regarding Group I and C as being highly similar (if not identical) in terms of the basis of their discrimination behaviour.

It is suggested, that in the case of Group SS, the specific stimulus value is determined by the ratio between the stimulus and the invariant background (i.e. the stimulus tray and plaque). Thus, when the stimulus tray is made darker, to match Stimulus four, the ratios specifying particular stimulus numbers are changed. In equivalence testing, Stimulus six comes to resemble Stimulus four, and Stimulus four comes to resemble Stimulus two - and if it is the case that a ratio determines the stimulus, as outlined above, then when Pair 4-6 are presented in equivalence testing, they resemble Pair 2-4, and choice behaviour is correspondingly shifted. In the case of Pair 2-4 being presented for equivalence testing, Stimulus four will come to resemble Stimulus two and Stimulus two will come to resemble some stimulus value much 'lighter' than stimulus two. Thus, it would be predicted that the bulk of choices should be for Stimulus four (i.e. resembling Stimulus two, but still the nearest value to Stimulus four). The bulk of responses were, in fact, made in this way.

It could be the case that the stimulus tray operates in the same way for subjects that have learned to discriminate in a relational manner. However,/

However, the current equivalence testing conditions would not detect whether this were the case or not. The following experiment serves to determine the involvement of the stimulus tray in establishing relationships between stimuli that differ in brightness.

EXPERIMENT 7 (3)

INTRODUCTION

Just as experiments in the previous chapter determined that visual referents were involved in the identification of specific values, so the previous experiment has determined what is the referent for the identification of specific brightness values. However, in discriminating between two stimulus values which differ in brightness by relating the two stimulus values (as Group I and Group C appear to do), subjects could either ignore the referent of the tray and, simply, relate the two stimuli, or they could relate each stimulus to the referent of the tray and then relate the two 'ratios' that they have perceived. The latter case involves visual referents outwith the discriminanda, the former case does not. The current experiment serves to determine the role of the stimulus tray.

The procedure adopted is similar to that used in demonstrating simultaneous brightness contrast in humans. The procedure is adapted for use with non-verbal animals.

METHOD

Subjects

Only six subjects took part in the current experiment - those comprising Group I and Group C.

Apparatus/

Apparatus and Stimuli

The same W.G.T.A. as was used in previous experiments was used in Experiment 7 (3). In addition to the matt white stimulus tray, two modified trays were constructed. These trays had one half painted matt black and one half painted matt white (one tray had its left side painted matt black and the other tray, its right side). Two sets of stimuli were contructed for the current experiment: One set was identical to the training set, the other set was identical to the training set but was not mounted on plaques as were the training set.

Procedure and Design

All subjects were treated in an identical manner. Testing was carried out over two consecutive days. Prior to each day's testing, subjects were given twelve differentially rewarded training trials following the procedure of Experiment 1 (3). As has been the convention prior to equivalence testing, no more than one error was allowed during these trials, otherwise the erring subject was returned to the discrimination procedure and required to re-reach the criteria of Experiment 1 (3). Following the first twelve trials of the day, a series of twenty-one trials were given - eleven of which were interpolated training trials with differential reward and using the normal, plaque-mounted stimuli of the training pool whilst the remaining ten were non-differentially rewarded equivalence trials using the modified stimulus trays and a pair of identical stimuli (equal in brightness to Stimulus four) which were not plaque-mounted. This pair of stimuli replaced the training stimuli for these trials. For each ten equivalence trials, the two stimulus trays were used in

a/

a randomly alternating manner.

RESULTS

During the two days of testing, four errors were made during the interpolated training trials (i.e. four errors out of one hundred and thirty-two trials). During the equivalence testing trials, however, far from responding at chance, the subjects showed a strong choice bias. The results are recorded in Table 8 (3), with associated probability values. Three subjects showed a significant preference for the stimulus on the white background ($p < 0.002$ to $p < 0.012$, two-tail test), two subjects showed such a preference which was not significant ($p > 0.4$ and one subject showed a significant preference for the stimulus from the black background ($p < 0.001$ for a two-tail test).

Except for one subject, a preference was shown for the stimulus on the white background. A Binomial Test showed that, in terms of the total number of trials, significantly more responses were made to the stimulus on the white than on the dark background ($p < 0.001$ two-tail test).

DISCUSSION

Five of the subjects produced results that are consistent with the view that relational learners relate the individual stimuli to some referent (the tray) before they relate the stimuli of the pair. Indeed, it appears as though in brightness perception within the constraints of the current experiment, the stimulus is defined in relation/

Subject	Choice Black	White	Associated p-value
1	3	17	0.002
2	7	13	0.264
3	1	19	0.001
7	8	12	0.410
8	4	16	0.012
9	20	0	0.001 *
Total	43	77	0.001

Table 8(3). Distribution of responses during the equivalence testing of Experiment 7(3), and associated p-value.

Note: 'Black' refers to stimulus presented on the black background. 'White' refers to stimulus presented on the white background. Each equivalence testing tray was half-black and half-white.

Note: * refers to a difference in the oppoaite direction to the rest of the subjects. All p-values are 2-tailed.

relation to some environmental referent irrespective of whether its value is to be subsequently conserved or related to some other brightness stimuli. It could be argued that the ratio between the stimulus tile and the referent is the (effective) stimulus.

Lashley (1938) has demonstrated similar effects in rats using a Jumping Stand and Wilson (1971) with rhesus monkeys. In these cases, however, subjects were having to judge particular stimulus values and in this respect differ from the general question asked of the relational learners of the current experiment. A further study which is worthy of note, here, is one in which parakeets were trained on a brightness paradigm similar to that of Group SS of Experiment 1 (3). Campbell and Kral (1958) by manipulating the brightness background shifted the subjects' responses from a rewarded to a previously non-rewarded stimulus. In this case, too, subjects were highly likely to be so-called absolute learners (if the results of the current and the previous chapters are considered), and, thus, differ from the current case.

It appears as though only one subject responded to the background and not to the stimuli.

SUMMARY AND CONCLUSION

The paradigm of Experiment 1 (3) encouraged one group of subjects to conserve a specific stimulus value (brightness) from a varying discriminanda, whilst the other remaining subjects were encouraged to conserve a relationship between the stimuli of the discriminanda. The results of this experiment reflected the superiority of the ability to retain intra-discriminanda relationships over the ability to retain specific stimulus values that was found in the corresponding experiment of the size series - although not to the same extent. However, unlike the case in the size series, specific external (potential) sources of interference did not produce the disruption of retention of the specific brightness that was, on the basis of the size experiment, predicted. The interpretation of this result, however, is not easy, since it could reflect the test-sophistication of the subjects (i.e. novel stimuli configurations no longer capture the subjects' attention to the extent that they did early in the size series) or some inherent difference between the two 'dimensions' with respect to specific stimulus retention. However, the learning-set data does illustrate, further the relative lability of specific stimulus retention - and the brightness series of experiments, taken as a package are consistent with those of the size series, in this respect. The (theoretical) position of Wertheimer (1959) and the position developed in Chapter 1, receive further support.

The proposition that, in the initial brightness discrimination training of Experiment 1 (3), both so-called relational and absolute learning was/

was achieved, is strongly supported by the results of the learning-set experiments - particularly the Trial one data - where the ability to conserve intra-dimensional relationships, and a specific stimulus value, was put to the test over a wide range of stimulus pairs. That a true rule of relation had been acquired by Group R and SSI, as opposed to a general response strategy, was shown not only by the Trial one data but also by the differential responding of Group C and Group I in face of consistent and inconsistent reward contingencies. In this respect, the results of the learning-set experiments of the size and brightness series are in close agreement.

The further purpose of the brightness series of experiments was to identify the relationships that (on the basis of the position developed in Chapter 1) need to be involved in the retention of specific stimulus values. The relationship between stimulus and immediate ground (i.e. the tray) was found to be of prime importance for the squirrel monkeys and, in this respect, is consistent with the results using other non-human species (for example - Campbell and Kral 1958 and Lashley 1938, as well as the more recent work of Wilson 1971). However, it was also found that such a relationship is involved in the discrimination behaviour of the relational learners. That is, it appears that the specific stimulus values of the two-stimulus discrimination made by Group R and Group SSI are specified with the stimulus tray as the referent, and then the relationship between these two values is conserved in relational discrimination learning. In the simultaneous contrast demonstration of Experiment 7 (3), it does not appear to be the case that the relationship between the two stimuli/

stimuli of the discriminanda is computed from, simply, within the discriminanda. In this respect, the way in which the relationship between the stimuli of the discriminanda are computed appear to be radically different for the continuum of brightness and size. In the latter's case, the relationship between the discriminanda must be computed entirely from within the discriminanda, since when all opportunity to relate the discriminanda to visual referents (as appears to occur in relational brightness discriminations) is eliminated in the luminous testing condition, the intra-discriminanda relation is conserved. It does not appear likely that the egocentric referents are used in place of exocentric referents to specify individual stimulus values prior to their being related, since the performance of specific stimulus learners has shown that the egocentric referencing system does not operate in the presence of the visual context.

Some relationships involved in the discrimination between <u>objects</u> that differ in size have been identified as have some relationships involved in the discrimination between stimuli that differ in the <u>attribute</u> of brightness. The following chapter examines a relationship which is involved in discriminations between patterns of stimuli which differ in their <u>spatial</u> <u>organization</u>.

C H A P T E R 4

RULES OF RELATION INVOLVED IN DISCRIMINATIONS BETWEEN STIMULUS PATTERNS THAT DIFFER IN THE ORIENTATION OF THEIR SPATIAL ORGANIZATION

The preceding chapters were concerned with experiments involving discriminations along the dimension of size and of brightness, and a number of types of relationships involved in such discriminations were identified. The current chapter is concerned with experiments involving the perception of patterns which differ along the dimension of orientation, and a further type of relationship operating along this dimension is identified and its importance with respect to theories of pattern recognition is discussed.

E. Gibson (1963) has made a useful distinction between theories of pattern recognition in a review of perceptual learning - she distinguishes between those based on a template-matching process and those based on a process involving the detection of individual features. In models involving template-matching, each new input is compared with a stored standard in recognition, whereas in models involving feature-analysis, the presence of particular parts is decisive. Such a distinction reflects an earlier one of Minsky (1961) in his reference to the different ways computers could be programmed to simulate (and carry out) recognition tasks. Neisser (1967) reviews the series problems that template-matching models encounter, which can be summarized by noting that whilst such models could, in the theoretical sense, easily answer the question 'Are these two patterns identical?', they would find considerable difficulty in answering the far more frequent and biologically pertinent question 'Are these patterns similar?', since to do so would require the operation of some continuum of similarity and the establishment of parameters of the same. It has been this problem that has proved to be the stumbling block/

block of the template-matching approach to pattern recognition - since it is required for recognition, that the stored template matches an incoming pattern, regardless of the latter's size, displacement and often degree of rotation (in the case of visuo-spatial patterns, for example). It is only Gestalt psychology that has managed to accommodate this problem in anything other than the trivial sense by assuming that such a process simply exists. The basic feature of template-matching models of pattern perception is, then, that some holistic template is stored within the perceptual system and used to detect the presence of absolutes of pattern in the environment. When such a match between templates and pattern occurs, the perception is inevitable.

The other class of model that E. Gibson does distinguish, contains those in which single features (or collections of single features) rather than unanalyzable holistic patterns are of prime importance. With such models, the task has been one of identifying the features or variables that are used in specifying a pattern which comprises a large number of features - i.e. to identify what is sufficient and necessary for a particular pattern to be recognised. (Since it is not the intention of the current author to review the many feature-analyzing models of pattern perception, only a number of such models as is necessary to convey the flavour of the approach will be included, below).

Hebb (1949, 1959) in a comprehensive theory of behaviour takes issue with template-matching models of perception, in general (and that of Gestalt psychology, in particular). The basis for pattern recognition is/

is the formation of functional groups of cells in a network called 'cell-assemblies' which come to respond together to particular features of patterns in the environment. These features are simple by any standards and consist of lines and angles. Of these simple features, he writes (Hebb 1949, page 81):

"We may therefore consider that these things are among the elements from which more complex perceptions develop."

In the same way that cell-assemblies develop from the repeated firing of specific collections of cells (i.e. as a result of the modification of their connecting synapses) in response to repeated presentations of specific features of the environment, so collections of cell-assemblies become linked when the corresponding collections of specific features are invariably presented together (as in the case of a complex pattern) - until the activation of <u>one</u> cell-assembly of this collection (i.e. by a single feature) is sufficient to activate the whole collection (i.e. the whole pattern). Thus, in Hebb's system, a single feature (or a relatively small number of them) can cause the recognition of a complex pattern, and in this respect is different from the holistic template-matching theories, previosly referred to.

However, in one important respect, both types of theory are identical in that they involve the operation of inflexible 'detectors' which are activated when absolutes of the environment are encountered - and in both cases, once the detectors have been activated, the ensuing perception is <u>inevitable</u>. The basic belief that the environment is highly structured and that perception involves the disembedding of such/

such structure (in terms of the absolutes referred to, above) is a central assumption of the more recent feature-analysis models, too. Such approaches are exemplified (although, by no means, exhausted) by those of Deutsch (1955), Dodwell (1957) and Sutherland (1957). Dodwell (1970, 1971) and Sutherland and Mackintosh (1971), for example, detail ways in which many of these theories (both behavioural and 'neurophysiological') have been considerably updated in light of the continuing emergence of new behavioural and physiological evidence. However, the updated theories continue to rest on the assumption that the process of perception, largely, consists of the detection of absolure characteristics of the environment.

Chapter 4 provides behavioural evidence which suggests that this is not the case. Feature-analysis, in general, and Dodwell's theory, in particular, (a more detailed account of which is given, later, in the current chapter) as well as the approach of Gestalt psychology to pattern perception, is found to be deficient. The stimulus patterns used in Chapter 4 can be most conveniently be described as being made up of collections of discrete, identical elements which come to be organized on the basis of what Gestalt psychologists have called the Principle or Factor of Proximity - and through such an organization, orientation is perceived.

Principle of Proximity

Gestalt psychologists have promoted the view that discrete elements of a stimulus array can form cohesive units according to that which they have called the Principle of Proximity (all other attributes of the elements/

elements being equal for maximum effect). This inductive generalization allows them to predict in new arrays which of these elements will be perceived as belonging to a unitary group or whole, and which will not. The smaller the distances between the elements of a potential group (as compared with the distances between these elements and elements outwith the group) the more cohesive will be that group. Wertheimer, one of the founders of the Gestalt approach, writes (Wertheimer 1923, page 311):

". . . one sees a series of discontinuous dots upon a homogenous ground not as a sum of dots, but figures. Even though there may be a greater latitude of possible arrangements, the dots usually combine in some 'spontaneous', 'natural' articulation - and any other arrangement, even if it can be achieved, is artificial and difficult to maintain."

and writes, further, in reply to his question as to whether such articulation follows any definite principles:

". . . the form of grouping is most natural which involves the smallest interval . . . . That the principle holds also for auditory organization can readily be seen by substituting Tap-Tap, pause, Tap-Tap, pause, etc., and so on for others."

Lashley, a protagonist of the gestaltist position, represents this view in a different way, and writes (Lashley 1949, page 35):

". . . the nervous system is not a neutral medium on which learning imposes any form of organization whatever. On the contrary, it has definite predilections for certain forms of organization and imposes these forms upon the sensory impulses which reach it."

The gestaltist claim is that such a predilection manifests itself in the/

the perceptual effects which they ascribe to (or, more properly, describe by) the principle of proximity and that they are, largely, independent of learning. There is evidence for the operation of such a principle in both the human and the non-human species, which is detailed below.

The phenomena associated with the operation of this principle in human perception are well-known and stimulus arrays where they are readily demonstrable can be found in almost any introductory textbook to perception - for example, Forgus (1966, pages 112-118), Dember (1964, pages 162-167) and Hochberg (1964, page 68) as well as in the original writings of the Gestalt psychologists, themselves - for example, Wertheimer (1923) and Koffka (1936, pages 164-168). The Gestaltists have been little concerned with the aetiology and the origins of these effects, since they have found them to be so spontaneous, reliable and universal to detract nothing from their claim that they are of an 'autochthonous' and, largely, innate nature - a claim in keeping with (if not directly derived from) the standpoint of one of the, then, contemporary metaphysical views (i.e. Kantian). This observation is supported by Piaget who writes in respect of the Gestaltists' indifference to such matters (Piaget 1971, page 248):

"In the case of development, supposing the gestalt to be regulated by highly generalized laws of the equilibrium of fields, then by definition it must be superior to any kind of development and, in consequence, either suprehistorical or ahistorical. However, neither biology nor the psychology of cognitive functions can be limited to "forms" of given unchanging kind, since the central problem in both cases concerns the origin of forms and their elaboration from the functioning stage upward. According to Gestalt structuralism, structures are prior to any kind of functioning. In fact, they seem to eliminate functioning altogether by absorbing it into ahistorical structures."

Principle/

Principle of Proximity - Non-Human Animals

It was mush less easy for the Gestaltists to find evidence of these effects in non-human species with the same directness as in humans, since, in the latter's case, subjective experience and verbal reports of subjective experience served as data. However, Hertz (1928, in Ellis, 1938), in a detailed study of the jaybird's ability to remember which elements of a configuration of identical elements (in fact, configurations of identical plantpots!) was associated with reward, has produced evidence which suggests that the principle does, indeed, operate in such an animal. She concludes, in referring to such principles (Hertz 1928, pages 251-252):

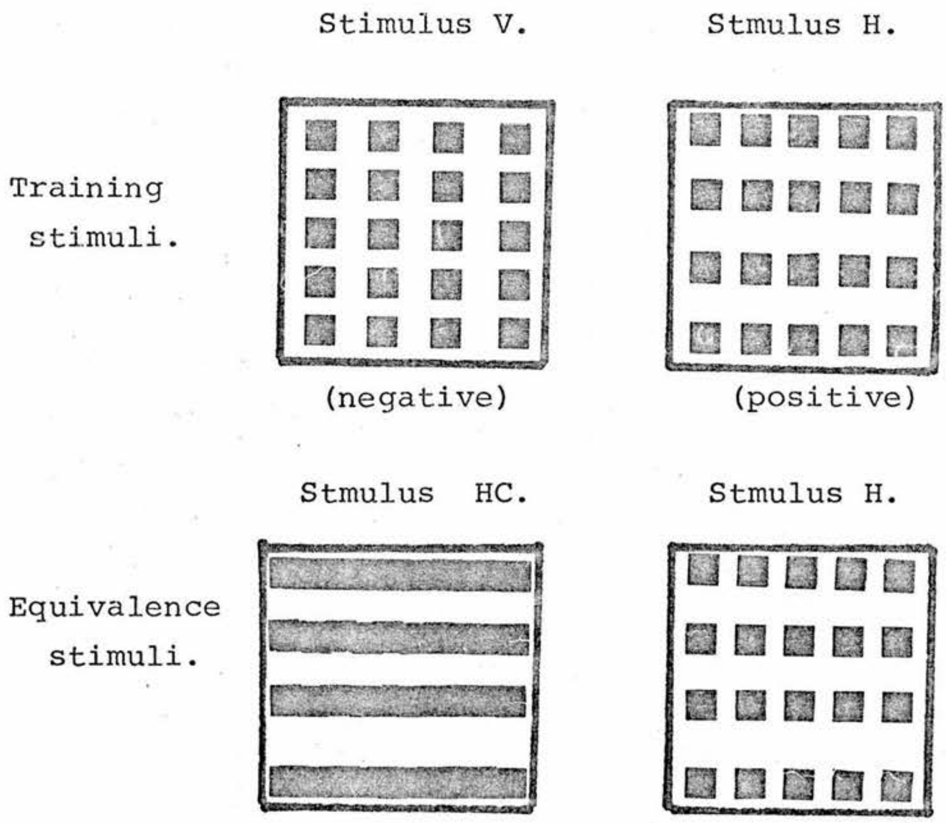
"To characterize in a single statement the results of our present study we may say that the perception of these birds is manifestly much nearer that of human beings than one might have at first thought possible. There seems every reason to believe that the organization of their visual field is essentially the same as our own."

Group membership in this case appears to be based on the contiguity of elements in the same way as has been described for humans. That such contiguity is an important factor in both learning and perception has been well demonstrated in non-human animals - for example, Köhler (1929), Klüver (1933) and Lashley (1949). Indeed, the Law of Effect is a description of precisely this phenomenon, except for the fact that contiguity is time - rather than spece-dependent.

Krechevsky (1938a) investigated the effects of spatial proximity (in the sense used in the well-known demonstrations of the same, using arrays cited above) using a discrimination learning paradigm and has produced/

produced more detailed evidence suggesting that non-human animals can, indeed, group discrete elements of an array according to the principle of proximity, to mush the same effect as humans. Using a Lashley Jumping Stand, he taught eight pigmented rats to discriminate between Stimulus H (positive) and Stimulus V (negative) of Figure 1 (4), simultaneously presented. That they learned the discrimination in a mean of only one hundred and ninety trials indicated it to be of only "moderate difficulty" (Krechevsky 1938a, page 244); that it was learned at all suggested to him that some differential organization must have occurred (possibly on the basis of proximity) - a claim further substantiated by results of non-differentially rewarded equivalence tests carried out following each subject reaching criterion on the original discrimination (using positive Stimulus H, and its continuous version Stimulus HC - see Figure 1-4). Five rats unambiguously chose the continuous version of the positive stimulus over the positive stimulus, itself, and three rats responded at chance on the equivalence tests. In <u>no</u> case did any rat show an overall preference for the positive stimulus, even though it was available at every choice. He has interpreted these results as indicating that not only is the principle of proximity effective in rats, but also the Law of Prägnanz - the forces of attraction that exist between the internal representations of the discrete elements of the array (proximity) coalesce into overall wholes (Prägnanz) that better resemble the continuous version of the positive stimulus than the original discontinuous version, itself, when both are simultaneously present in equivalence tests. Koffka (1936) writes:

"The principle was introduced by Wertheimer, who called it the Law of/



<u>Figure 1 (4).</u> <u>The stmulus patterns used by Krechevsky (1938a) in his demonstration of the operation of the principle of proximity in rats</u>.

Note: the matrix-patterns are only representative of the actual patterns used (i.e. they contained a different number of elements and 'lines').
This also applies to Figures 2(4) and 3(4).

of Praganaz. It can briefly be formulated like this: psychological organization will always be as 'good' as the prevailing conditions allow. In this definition the term 'good' is undefined. It embraces such properties as symmetry, simplicity and others . . ."

The previous experiments indicated to Krechevsky that following acquisition training, organization according to the principle of proximity is evident, in rats.

A further experiment was designed by Krechevsky (1938b) to determine whether this organization was a function of the (e.g. positive) stimulus array, itself, or whether other factors influenced the organization. He writes (Krechevsky, 1938b, page 499):

"(1) Assuming the validity of the principle of autochthonous factors of organization in the sensory field, are these factors alone sufficient to account for the 'look of things', in all cases, or is some other set of factors necessary to make <u>effective</u> the operation of these principles. In other words, are the determining forces making for a particular organization to be found outside the specific sensory field in question and not derivable from the distribution of the field?
(2) Assuming that the latter answer is the correct one for certain cases, then what is the nature of these necessary but non-sensory field forces, i.e. what are the conditions which permit the functioning of the autochthonous principles of organization in these cases?"

Krechevsky has suggested that such a non-sensory field force could be problem difficulty, i.e. if the problem <u>required</u> the subject to organize the array according to the principle of proximity, then he would; if some other (in some sense, perhaps, more 'simple') attribute could form the basis for the discrimination, then such organization would not, or need not, occur. Referring to the first experiment where organization according to the principle of proximity is claimed as the basis for the discrimination, he writes (Krechevsky, 1938b, page 501):

". . . the/

" . . . the situation as a whole (the problem-situation) required that a given visual organization be made. Under those conditions of need the animal did finally (the present author's achieve organization in his perception."

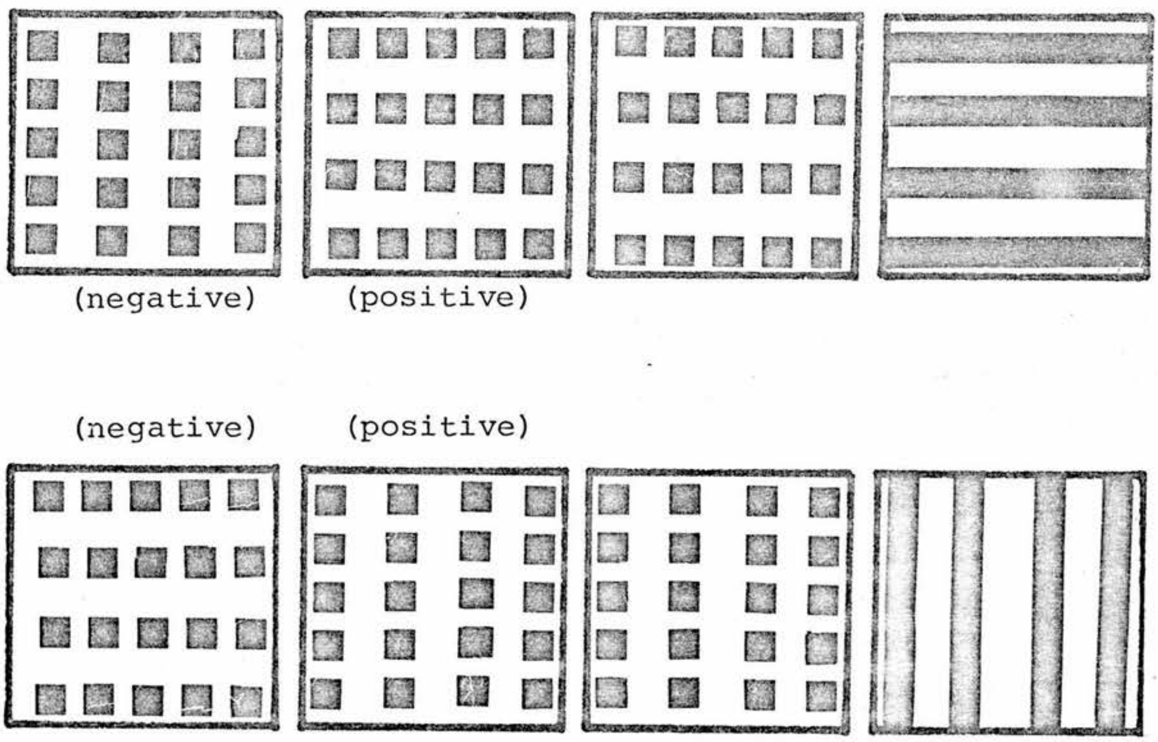
The design of this experiment (Krechevsky, 1938b) was basically similar to the previous one - nineteen pigmented rats of Group I were trained with Stimulus H and V of Figure 2a (4), (a 'hard' discrimination - Krechevsky's terminology). Subgroup Ia was rewarded for responding to Stimulus H, and Subgroup Ib was rewarded for responding to Stimulus V. Twenty three rats of Group II were trained with Stimulus H or V and with Stimulus X of Figure 2b (4), (a 'hard' discrimination). Subgroup IIa were rewarded for responding to Stimulus V and Subgroup IIb to Stimulus V, i.e. Stimulus X was never rewarded. As in Krechevsky (1938a), non-differentially rewarded equivalence tests were given during which each subject's positive stimulus was paired with its continuous version. In terms of trial one performance during the equivalence trials, seventeen out of twenty subjects of Group I chose the continuous version of the positive stimulus over the discontinuous version (i.e. the positive stimulus, proper) whilst only three of the twenty-three subjects of Group II chose the continuous version of the positive stimulus. Performance over the first ten equivalence trials yielded similar results.

It is clear from these results that those subjects who had experienced the 'hard' discrimination preferred the continuous version of the positive stimulus to the positive stimulus, itself, in equivalence tests, whereas those experiencing the 'easy' discrimination preferred the actual positive stimulus. Krechevsky concluded that the responses of/

Subgroup Ia.

Training Stimuli. Equivalence Stimuli.

Stmulus V. Stmulus H. Stmulus H. Stmulus HC.



Stimulus H. Stmulus V. Stmulus V. Stmulus VC.

Training Stimuli. Equivalence Stimuli

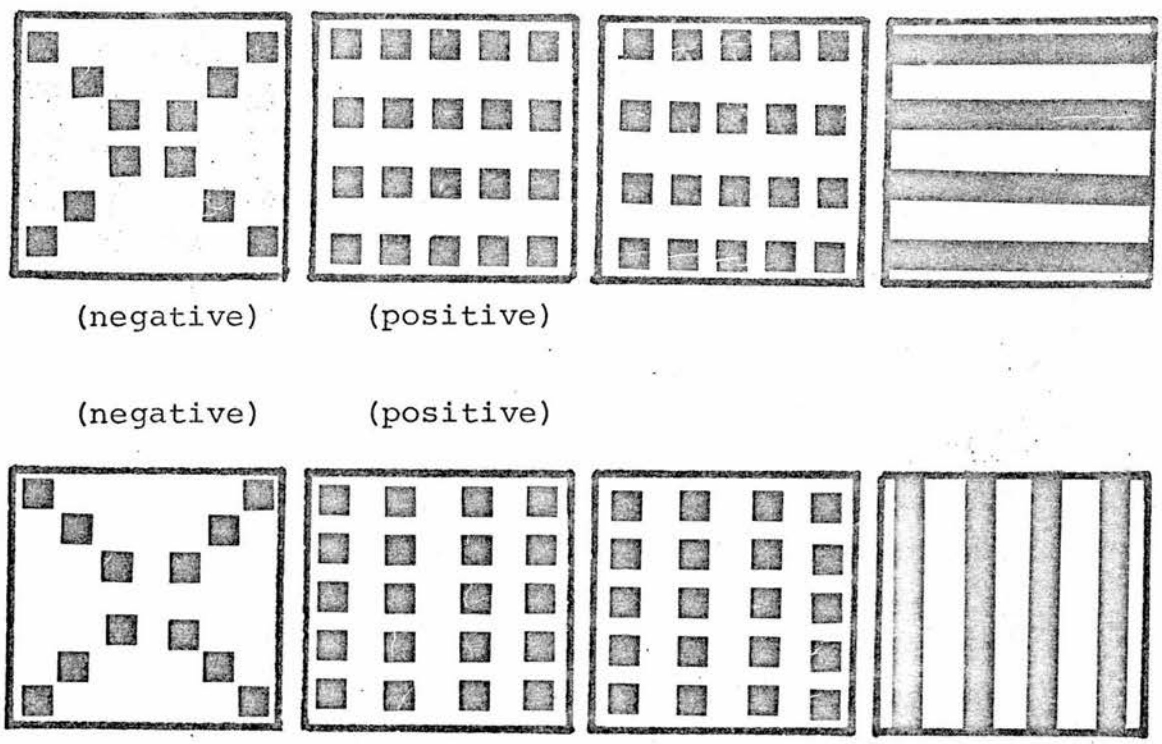
Subgroup Ib.

Figure 2a (4). The stimulus patterns used by Krechevsky (1938b - the 'hard' condition) in his investigation into the factors contributing to the operation of the principle of proximity in rats.

Subgroup IIa.

Training Stimuli. Equivalence Stimuli.

Stmulus X. Stmulus H. Stmulus H. Stmulus HC.



Stimulus X. Stmulus V. Stimulus V. Stmulus VC.

Training Stimuli. Equivalence Stimuli.

Subgroup IIb.

Figure 2b (4). The stimulus patterns used by Krechevsky (1938b - the 'easy' condition) in his investigation into the factors contributing to the operation of the principle of proximity in rats.

of the two groups of rats, following discrimination training, differ because their respective 'needs' differ (as governed by the problem-difficulty).

That Krechevsky's attention was focused closely upon the learning phase of the experiment and focused in terms of problem-situation or problem-difficulty, as the major factor in the aetiology of the effects attributed to the operation of the principle of proximity, and that no other possible factors have been considered, stems from the influence of Tolman, one of Krechevsky's contemporary psychologists. Tolman's (1933) concept of the sign-gestalt promotes the view that gestalten need not be perceptual effects, alone, but that they most often are perceptual-effects-with-a-purpose. He writes (Tolman, 1933, page 395) of sign-gestalten, that they are:

". . . some specific larger whole in which this merely pictures (i.e. perceptual) configuration with itself be embedded as one term in a larger means-end proposition such as 'that chair, if sat on will lead to rest'".

In Krechevsky's terms, the purpose is supplied by the problem-situation/ problem-difficulty without which the gestalten (i.e. the organization according to the principle of proximity) does not come to be constructed, by the end of the discrimination training. His position following these two experiments can be summarized as follows:

1. A non-human species (the pigmented rat) can come to organize discrete elements of a visual array according to the principle of proximity, which operates in conjunction with the law of Prägnanz.

2./

2. In the cases tested, this organization does not solely depend upon the visual array, itself, but also on the current 'needs' of the organism - organization only occurring where the problem-situation eventually forces it to occur.

3. If such 'needs' are absent, some other basis for erecting the discrimination is likely to occur - for example, differential brightness. That is, great stress is placed upon the learning phase of the discrimination process.

Dodwell (1965, 1970a, 1970b) and Dodwell, Neimi and Litner (1970) have confirmed the results of Krechevsky's first experiment (1938a) and the 'hard' condition of his second experiment (1938b), i.e. that continuous versions of the positive stimulus are preferred to the original discontinuous positive stimulus in equivalence tests following discrimination training. This preference, Dodwell (1965) has called the Anomolous Transfer Effect (A.T.E.) - 'anomolous', since the trained positive stimulus is present but not preferred when a choice is offered. Dodwell, however has questioned the ambiguity of the A.T.E., as demonstrated by Krechevsky, on two grounds:

1. He submits that it is conceivable that rats have a preference for smooth stripes over their discontinuous version, in general. The A.T.E. is then explicable in terms of this general preference. (Although no evidence is adduced in support of this, neither does the present author know of any, nor is it clear what *a priori* ground exist for suspecting such - except in terms of the following.)

2./

2. He, further, submits that it is conceivable that rats can respond to the 'novelty' of the stimulus rather than to the stimulus characteristics, themselves. The A.T.E. is then explicable in terms of this general preference for novelty. (There is supportive evidence for this contention, although none is cited by Dodwell, Dember (1956), and several studies cited by Halliday (in Weiskrantz, 1968), for example).

Dodwell (1965) has, therefore, conducted an experiment, the design of which enabled the two possible additional explanations of the A.T.E. to be examined and help resolve the inconclusive nature of Krechevsky's results. In addition to the test trials of Krechevsky's design (1938b - the 'hard' condition), Dodwell has included equivalence test trials in which the discontinuous negative stimulus was paired with its continuous version (Krechevsky only used the positive stimulus and its continuous version in his equivalence tests), as in Figure 3 (4). Occurrence of the A.T.E. using the negative stimulus and its continuous version in equivalence test trials would dispose of the so-called 'novelty' problem, since the subject in demonstrating the A.T.E. would need to choose the original negative stimulus, with which it is familiar, over its (novel) continuous version. Further, if before each subject entered the discrimination training procedure it could be shown that the subject had no preference for either of the stimuli used in the 'negative' equivalence test trials, or if there were a preference, it was for the continuous version of the stimulus, the occurrence of the A.T.E. in these trials would dispose of the so-called 'preference' argument. In Dodwell's experiment, rats which did show such a bias in preference tests were placed in discrimination training/

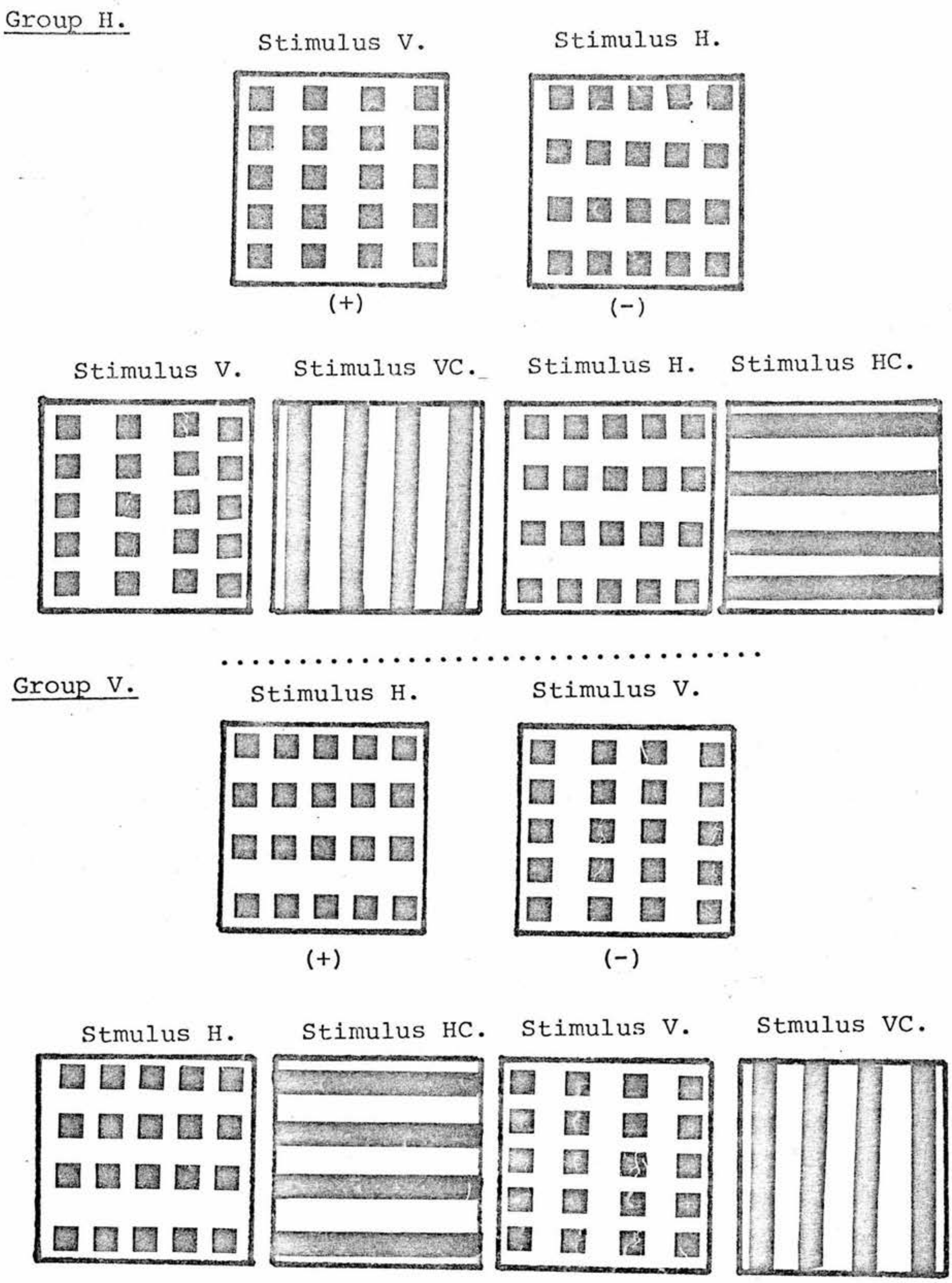


Figure 3 (4). The stimulus patterns used by Dodwell (1965).

(see over for notes)

Figure 3(4). The stimulus patterns used by Dodwell (1965) in replicating the results of Krechevsky, and including necessary 'control' conditions.

Notes: The training stimuli used in Dodwell's experiment are the single pairs of Figure 3(4). The equivalence stimuli are presented in double pairs - the pair on the left, used for testing for the 'positive' A.T.E. and the pair on the right, the 'negative' A.T.E.

training groups appropriate to the above rationale. The results confirmed Krechevsky's original findings (i.e. the positive A.T.E.) and also produced evidence for the negative A.T.E., even with subjects who showed an original preference for the continuous version of the negative discontinuous training stimulus.

A further series of experiments carried out by Dodwell and his colleagues, demonstrated that the A.T.E. was neither species-specific nor specific to any type of apparatus. Dodwell (1965) has shown the effect with Sprague-Dawley hooded rats using a Jumping Stand; Dodwell (1970a) has shown the effect with the same species using a highly modified W.G.T.A., and with grey squirrels using a modified Jumping Stand and Dodwell, Litner and Niemi (1970) have shown the effects with squirrel monkeys using a semi-automated panel-pressing task. Further, Dodwell (1970b, page 83) promises to report of a "new form of discrimination apparatus" in which this effects has, also been produced. It appears that the A.T.E. is a most robust phenomenon.

Principle of Proximity - A 'Neurophysiological' Explanation

Whereas Krechevsky has interpreted these findings as being supportive of the general position of Gestalt psychology, Dodwell favours what he calls neurophysiological explanations of the A.T.E. He writes (Dodwell, 1970a, page 42) of Krechevsky's interpretation:

"Krechevsky interprets this finding in terms of stronger 'Gestalt forces of cohesion' in the smooth-stripe arrays. Such an explanation may have been acceptable at the time, but seems inadequate now in view of the great amount of information about mammalian vision which has accumulated in the meanwhile."

Dodwell's/

Dodwell's (1964 and 1970b) model of contour processing in the mammalian visual system involves the independent summation of horizontal and vertical contour elements in the visual array - patterns are evaluated in terms of these sums at a central 'recognizer'. Dodwell's model requires the mammalian visual system to be able to detect and register the elements comprising the horizontal and vertical components and to integrate the registered effects of the elements of a neurophysiological basis for contour-coding in the cat which is orientation-specific, but not position-specific (e.g. Hubel and Wiesel, 1962) and the, more recent, discovery of a similar system in the monkey (Hubel and Wiesel, 1968) provide supportive evidence for Dodwell's theoretical position. Especially favourable to Dodwell, is the fact that such a system also has the summation characteristics necessary for the operation of his model. Dodwell's interest in Krechevsky's original findings is not, therefore, surprising - since the stimulus patterns used in discrimination training are particularly suited to description by his model, and the stimuli of the equivalence tests particularly appropriate for testing predictions generated by the model, of subsequent transfer. In Dodwell's terms, what the subject uses of the positive stimulus (e.g. when Stimulus H is positive and Stimulus V, negative) is that <u>the sum of the horizontal elements of that stimulus is greater than the sum of the vertical elements</u> - or vice versa for the negative stimulus. These two sums, and the direction of their difference specify which stimulus is which - i.e. the spatial relations between the elements of the visual array have been reduced to a simple descriptor. Continuous versions of the discontinuous training stimuli, in this sense, following discrimination training,/

training, give a stronger index of 'positiveness' or 'negativeness', and this is the basis of the A.T.E., according to Dodwell.

It is clear from Dodwell's model that he considers the descriptor that the subject uses in solving the discriminations is derived from an array representing a single stimulus (be it positive or negative) - that each stimulus is encoded or processed unrelated to any external or internal frame of reference. In this respect, his position represents the approach of most feature-analysis models of pattern perception (especially now a plausible physiological basis for such feature-detectors does exist).

However, whilst Dodwell's model is in close agreement with the results of Krechevsky to which Dodwell refers in his experimental papers (and, indeed, with the general standpoint of Gestalt psychology), it is <u>not</u> in agreement with Krechevsky's other equally important finding contained in the same experiment, and which has been completely ignored by Dodwell in the development of his theory. In his experiment (1938b), Krechevsky has shown <u>that the influence of proximity seems to be limited to certain special conditions of training</u>: rats without an appropriate comparison stimulus fail to organize the matrix of discrete elements as predicted by the principle of proximity (i.e. Krechevsky 1938b - the 'easy' condition, whereas rats with an appropriate comparison stimulus do (the 'hard' condition). It appears that Dodwell's model can only accommodate the data of the 'hard' condition, making no reference to the other.

<u>Principle of Proximity - Human infants</u>

It/

It is important to note, at this point, that whilst it is held by writers of introductory textbooks to psychology in general and to perception in particular, that organization according to the principles of Gestalt psychology is more or less automatic and spontaneous, evidence does exist which suggests that, even in humans, this may not be the complete picture. Rush (1937), for example, has demonstrated that visual grouping according to similarity and proximity of the elements presented, tends to improve with age - infants finding it much less easy than juveniles. Lang (1966) has studied emotional reactions in response to the presentation of a variety of visual forms in 8-, 9- and 10-week old infants. The emotional behaviour was measured on a nine-point scale of 'pleasureful relaxation versus aversive tension'. Values low on the scale included smiling and an orientation towards the stimulus, values high on the scale included crying, head aversion, motionless tension or convulsive movements. The visual forms used were either regular or highly irregular in shape and each had a continuous and a discontinuous version (in the same sense as used in reference to the stimulus patterns of Krechevsky and Dodwell). At the age of 8-weeks (testing was done + two days of the target age) no differential response was made to the stimulus pool; but by the age of 10-weeks, the infants showed more relaxed responses to the regular forms than to the irregular ones - whether of a continuous or discontinuous variety. Lang has concluded that the discontinuous forms were not articulated in the 8-week old infant, whereas in the 10-week old infant they were. Elkind, Koegler and Go (1964) have reached a similar conclusion in a series of studies in which they have examined Piaget's decentration theory/

theory of the development of perception (as cited by these authors) - in which the perception of the infant is thought to be 'centered' or organized by principles similar to those which the Gestalt psychologists describe. With the passing of time, these principles are gradually replaced by operations of a more logical and mathematical kind, or 'decentered'. The age groups studied by Elkind et al were from 4- to 9-years old in steps of one year. They used stimuli configurations in which the elements were well-known objects (candy, fruit, toys, animals, for example) 'configured' to produce other well-known patterns (faces, fish, toys, for example). Subjects were asked to describe (exhaustively) what could be seen at each presentation, and their responses scored as 'part' or 'whole' responses. At 4-years of age, 'part' responses made up virtually <u>all</u> of the subjects' response repertoire, whereas at 9-years of age, only 21% of subjects fell into this category.

Bower, in a series of experiments, has used conditioning techniques to assess, more directly, the functioning of some of the Gestalt laws in infants. Using suppression of an unconditioned sucking response (as an index of 'surprise'), Bower (1965) has shown that proximity principle was not evident in infants as young as 4-weeks of age, but had appeared by 20- to 30-weeks of age. Using a head-turn conditioned to a figure containing three parts, Bower (1966) has also shown that at the age of 8-, 12- and 16-weeks, infants respond to the parts of the figures, separately - but by 20-weeks of age, the response to the 'whole' figure was greater than the sum of the responses to the parts, indicating that the relationships between the parts has by this age come to be an important part of the perception of the infant. Further experiments/

experiments by Bower (1967 and 1969) have produced similar results. Although Bond (1972), in a review of form perception in infants, has recently concluded that there is little evidence to suggest that the perceptions of infants differ qualitatively from adults, it would appear that the data of the experiments detailed above, suggest otherwise. It seems clear that, at least in the areas of the principle of proximity, the operation of Gestalt laws is not necessarily as automatic and spontaneous as is generally thought - and, in this sense, in agreement with the earlier findings of Kreckevsky with non-human animals.

Rationale for the Series of Proximity Experiments

In view of the fact that spontaneous organization of the elements into 'cohesive' units is not as ubiquitous a phenomenon of human perception as might have been supposed, it would seem to be important to pursue this at the non-human level, since even less is known about it, there. Krechevsky has shown that such organization is limited to certain conditions of stimulus presentation in training, but what it is about these certain conditions of training which produce the differential organization is not clear.

Krechevsky has decided to interpret his findings in terms of Tolman's 'sign-gestalt' (a perception-to-serve-a-purpose) which implies that whatever matrix-organization is imposed upon the physical stimulus by the time criterion is met, would not have been there at the beginning of discrimination training - since it is the very problem presented by the training paradigm that forces the organization to occur. Once this organization has been forced to occur in response to the problem-difficulty/

difficulty, it should be stable. Krechevsky writes (1938, page 518):

"Carrying our suggested analysis further, we would say that once this 'need' for discovering the significate of the discriminanda has been satisfied, one set of forces responsible for the sensory organization no longer functions and further organizations of the field do not occur very readily".

There are, however, several explanations of what might be occurring during Krechevsky's experiments that produce the differential responding indicative of differential organization of the matrix, under the two conditions of problem-difficulty. The design of Krechevsky's experiments (and the more recent ones of Dodwell) do not permit this ambiguity to be resolved. In the context of this thesis, (and particularly in relation to the current interest in feature-analysis models of pattern recognition) the several explanations are of interest since it is only when appropriate comparison stimuli are present that the principle of proximity operates - that is, only when particular stimulus configurations are <u>related</u> together, does the organization occur. The several explanations are as follows:

Hypothesis 1. It is suggested that the organization according to proximity could occur in both the 'easy' and the 'hard' conditions, <u>immediately</u> the array of any <u>single</u> matrix is received by the visual perceptual system. Lack of the A.T.E. in the 'easy' condition could indicate that the subject is using a more 'striking' or 'salient' difference between the simultaneously presented stimuli to solve the discrimination problem, at the expense of other differences which his perceptual system might still/

still be detecting. This would be similar to the so-called 'one-look' models of this type of discrimination learning which assume total concentration of attention upon a single stimulus-dimension of the stimulus complex for discrimination purposes (e.g. Zeamon and House, 1963). Even though it may be the case that the subject is perceiving other dimensions, he may be predisposed to learn only about one in particular under the circumstances of the experimental conditions (see Seligman, 1969), i.e. he may be predisposed to make response attachments to one 'perception' but not to others.

Hypothesis 2. It is suggested in this case, immediate organization of the matrix only occurs when it is simultaneously presented with an <u>'appropriate' comparison stimulus</u>. Krechevsky's 'easy' condition does not contain an 'appropriate' comparison stimulus, whereas the 'hard' condition does - and, hence, following this hypothesis, from the presentation of the stimulus pair in the 'hard' condition, the subject perceives the organized matrices; in the 'easy' condition, no such organization is produced. (What constitutes an 'appropriate' comparison stimulus, and what does not, will be discussed later in the text - for the present, the operational definition will suffice). During discrimination training, as in the case of Hypothesis 1, response attachments are made during training at appropriate point/

point on whichever is the dimension-of-difference.

The difference between this explanation and that of Hypothesis 1, is that in the latter, the organization imposed by the perceptual system upon the matrix is a function of nothing other than that matrix; whereas in the case of Hypothesis 2, matrix organization depends upon its being related to another matrix. However, in both explanations, the organization is an immediate, perceptual effect.

Two further explanations are possible, which serve to exactly complement the two outlined above. In the two previous hypotheses, organization under whichever condition it did occur, is postulated to be an immediate (and in this sense, perceptual) effect. Complementary explanations could be advanced in which the rationale is exactly as in Hypothesis 1 and 2, except for the fact that on the first exposure, no such organization occurs, but with prolonged training it comes to emerge. In these cases (Hypothesis 3 and 4), organization is not an immediate effect, but a perceptual-learning effect.

Clearly, this latter category embraces the explanation given by Krechevsky, although it is not possible to decide on the evidence whether Hypothesis 3 or 4 is the more applicable. Dodwell's explanation falls into the former category and since contour coding models of his type deal only with a single matrix, is consistent with Hypothesis 1. However, having made this statement, it becomes clear that the model is found wanting, since it follows that the matrix of Krechevsky's 'easy' condition ought to be organized in a way similar to the 'hard' condition, and it is not.

An/

An experimental design is required, which is a more critical test of the theoretical positions which are based on the detection of absolutes of pattern in the environment (e.g. the approaches of both the Gestalt psychologists, and Dodwell) - in respect of the (spontaneous organization of such matrices in simultaneous discrimination learning. The experiments reported in Chapter 4 are designed to this effect, and to assess the hypotheses outlined above.

EXPERIMENT 1 (4)

INTRODUCTION

In order to examine, further, the phenomenon described by Krechevsky (and Dodwell), it is first necessary to show that the phenomenon can be reproduced under the current laboratory conditions (i.e. subjects, stimuli, apparatus, procedure, etc.) - even though it has been demonstrated to be quite a robust effect in terms of these variables. To this end, Experiment 1 (4) in part, is designed to replicate Krechevsky's 'hard' condition of training and the subsequent equivalence tests and, also, Dodwell's confirmation of Krechevsky's findings, including his appropriate control conditions (i.e. Krechevsky, 1938b and Dodwell, 1965 and 1970a Experiment 1). More critical tests of spontaneous organization, however, are included along with the equivalence tests that have been conducted in previous studies. As in previous experiments, the subjects are forced to acquire an appropriate set based on proximity factors in the discrimination training phase of the experiment, but they are subsequently tested with a series of critical equivalence tests, to determine the extent to which organization based on proximity is retained when new comparison stimuli are provided. Experiment 1 (4) tests the hypothesis that organization of the matrix on the basis of proximity occurs only when appropriate comparison stimuli are present, using performance rather than sheer learning measures. More important, is the fact that each subject can be used as his own control in that equivalence/

equivalence tests can be run in which novel comparison stimuli are presented, when it is already known that the subject is able to organize matrices on the basis of proximity under the conditions of discrimination training.

Successful transfer of the organization of the matrices from discrimination training phase to those equivalence tests containing a matrix and an inappropriate comparison stimulus would suggest confirmation of Hypothesis 1 and 3, previously outlined. More specifically, this would indicate that the organization of the matrix does occur without any influences from outwith the matrix, itself. It would not, however, distinguish between so-called perceptual and perceptual-learning explanations of the organization (i.e. between Hypothesis 1 and 3). Lack of transfer from discrimination training to those equivalence tests containing a matrix and an inappropriate comparison stimulus would support Hypothesis 2 and 4, but would not distinguish between them.

METHOD

Subjects

Eight experimentally-naive, male albino rats (purchased from the Bush Farm Animal Holdings, Penicuik, Scotland) served as subjects. They were approximately 110-days of age at the onset of pretraining. They were housed in cages in groups of two or three in a colony room maintained under conditions specified by the Home Office (Cruelty to Animals Act 1876). Water was available for twenty-four hours per day but feeding was restricted to a three or four hour period following experimental sessions. M.R.C. Diet Two (vitamin enriched) pellets were/

were given during feeding periods, supplemented by diced carrot and apple once per week. Their only other source of food was wet mash available as reward during the experimental sessions (crushed M.R.C. Diet two pellets, mixed with water to a 'stiff' consistency).

Apparatus

A modified Lashley Jumping Stand was constructed from $\frac{1}{2}$" unpainted chipboard. The surfaces of the wood were coated with clear matt varnish to make cleaning processes easier.

The Stand had two door-aperture of dimensions 6" x 6" with their centres placed 11" apart. On the jumping side of each door-aperture was a ledge, slightly wider than the 6" aperture and 4" deep. Communication between the ledges was prevented by a vertical partition 14" high and projecting 6" from the plane of the door-apertures. (The ledges and partition are a modification of the original design - Lashley, 1930 - and added to facilitate speedier learning since no punishment occurs following incorrect responses, as the ledge prevents the subject from falling - for example, Mackintosh, 1963). The jumping platform was in the form of an elevated Y-maze with arms 4" wide. The two arms leading to the ledges in front of the door-apertures were 8" long and their centres of their leading edges were 11" apart, i.e. the leading edges were positioned in the centre of the door-apertures at their base and at the same height as the ledges. A typical jumping distance for subjects during experimental sessions was 8", but was different and variable for each subject. Behind each door-aperture was a large common ledge which housed the trough in which the reward was placed. The/

The doors were constructed of unpainted but varnished hardboard of dimensions 8" x 8", and were positioned on the reward side of the door-apertures.

The doors could either be locked shut, such that communication between the ledges and the reward trough was prevented, or left unlocked such that a light touch from the ledge side would cause the door to fall flat and permit access to the common platform and the reward trough. Any distraction from extraneous visual stimuli was greatly reduced by vertical, parallel sidewalls 24" apart and 24" higher than the top of the doors. They were sufficiently long to enclose the platform holding the food trough and also the choice-point of the jumping platform. The apparatus was lit by the testing room's roof light which was a 100-watt fluorescent strip whose long axis was positioned overhead and coincident with the longitudenal axis of the apparatus. White noise of approximately 60 db. was delivered by a 10" loudspeaker positioned behind the apparatus.

Stimuli

Five stimulus patterns were used in Experiment 1 (4), and positioned on that 6" x 6" portion of the 8" x 8" door coincident with the 6" x 6" door-apertures. Figure 4 (4) displays the five stimulus patterns that were used.

The background of all the stimulus patterns was the doors of the apparatus, painted matt black. Stimulus 1 was, merely, this matt black background with no markings (i.e. a 'blank' stimulus). Stimulus two and three were made up of matt white, adhesive P.V.C. stripes which/

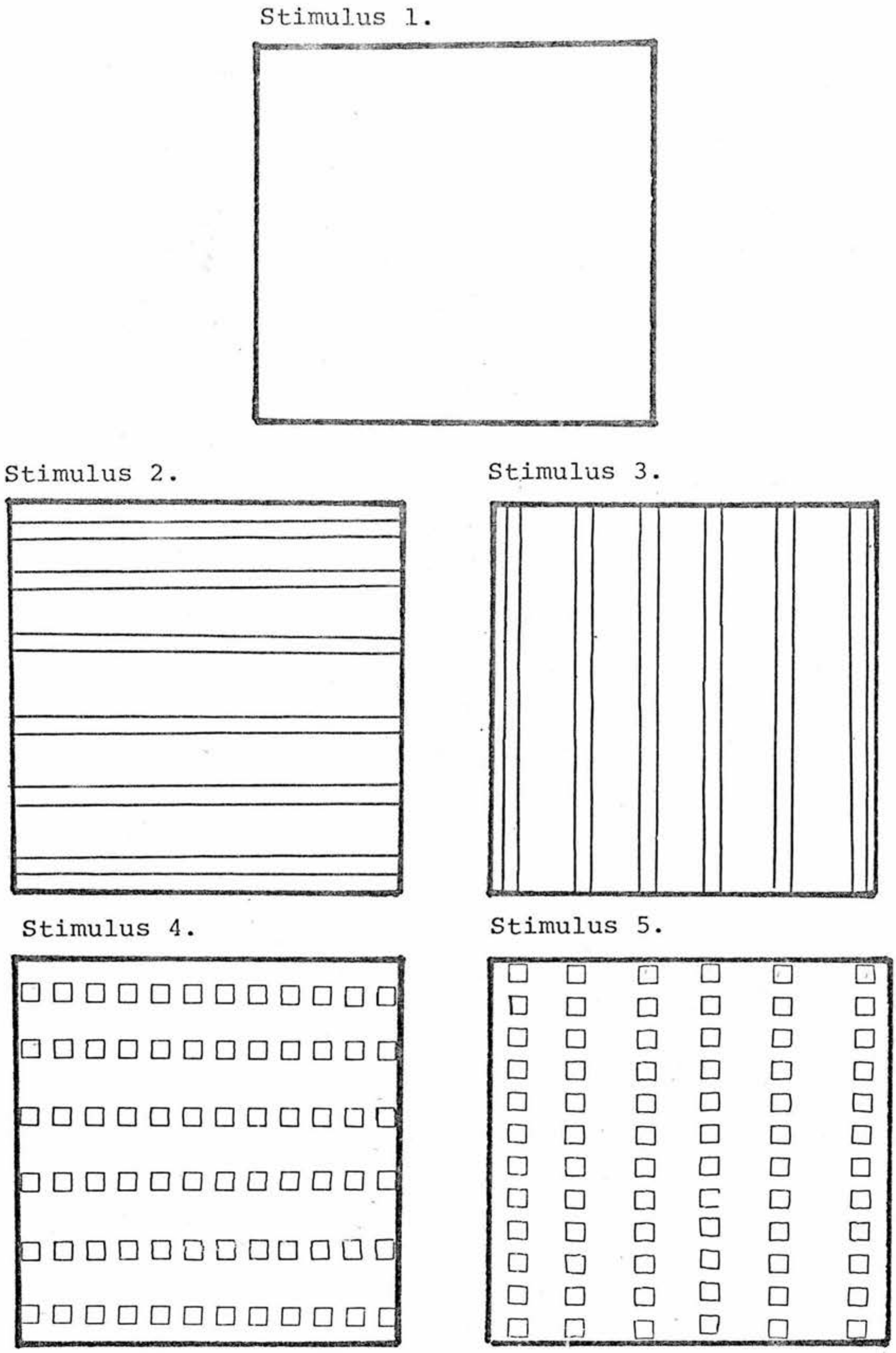


Figure 4 (4). The 5 simulus patterns used in Experiment 1 (4).

Note: The patterns are slightly less than half-size. The patterns are white on a black background.

which were $\frac{1}{4}$" wide and 6" long. There were six of them, positioned parallel to one another and $\frac{3}{4}$" apart (i.e. the centres of the stripes were 1" apart). The stripes of Stimulus two were horizontal, those of Stimulus three were vertical. Stimulus four and five were similar to Stimulus three and four, but were discontinuous versions. They were constructed of $\frac{1}{4}$" squares of matt white P.V.C., arranged in patterns such that the 'lines' that they represented were coincident with the stripes of Stimulus two and three (see Figure 4-4). Twelve such $\frac{1}{4}$" squares represented each stripe. The small distances between the squares (the intra-stripe distance) was $\frac{1}{4}$" and the large distance (the inter-stripe distance) was $\frac{3}{4}$". The centre-to-centre ratio of the elements comprising the 12 x 6 matrix was 2 : 1. The 'lines' represented on Stimulus four were horizontal, those on the other stimulus were vertical.

Four identical versions of each stimulus pattern were constructed, producing a stimulus pool of twenty. This was done to prevent subjects learning discriminations on the basis of features peculiar to one stimulus door, rather than the stimulus pattern, itself.

Shaping and Pretraining

Subjects were progressively adapted to a twenty-hour feeding schedule for a period of two weeks prior to the beginning of pretraining. During this period they were 'gentled' daily to reduce their so-called emotional responses, since Rink (1968) has demonstrated that rats handled in this way learn visual discriminations (i.e. horizontal vs vertical stripes) quicker than 'non-gentled' rats. Following this period/

period of adaptation, pretraining and shaping began.

Day one and two. Subjects received part of their daily ration of food on the reward platform of the apparatus. The jumping distance was reduced to zero and the doors were removed. Subjects were allowed to wander over the apparatus and its jumping platform during this period with their cage-mates. Throughout these two days, the subjects were periodically 'gentled' after being picked up, and replaced at the choice-point of the jumping platform and had to learn that in order to obtain their daily food ration, they had to travel along the arms, onto the door-ledge, through the door-aperture and approach the food trough.

Day three and four. Subjects were treated in a similar way to Day one and two, except that they were made to perform alone. They were picked up and replaced at the choice-point at least twenty times per day. During this period, the jumping distance was progressively increased to 3" or 4".

Day five and six. Unpainted, brown hardboard doors were gradually introduced during these two days - progressively narrowing the two door-apertures until they were completely covered and the only way the reward trough could be accessed was by pushing down one of the doors. An informal attempt to balance each animal's experience of the sides of the two doors was made by placing a large, immovable cube of wood on the jumping platform's arm of the greatly preferred side.

Day seven, eight, nine and ten. During the final four day of pre-training, twenty discrete trials were given per day with identical hardboard/

hardboard doors covering the apertures. During these four days, the jumping distance was gradually increased until it was the maximum that the subject could jump with 'confidence' (i.e. without prolonged delays before jumping). Further, on each trial, one of the two identical doors was locked (the location of the 'correct' door was determined and varied from trial to trial using a Fellows sequence - Fellows, 1967).

The subject was placed on the base-arm of the jumping platform and allowed to move to the choice-point and jump across to whichever ledge was preferred. If the ledge led to the unlocked door, then this was to be pushed flat and the subject allowed access to the food trough for 15-seconds. Following this, the subject was returned to the restraining cage for the 10-second inter-trial interval during which time the appropriate doors were locked and unlocked. Following the inter-trial interval, the subject was taken from its restraining cage and placed, as before, on the base-arm of the jumping platform for the next trial. If, on any trial, the subject finished on the ledge leading to the locked door (the 'incorrect' door) then it was restrained on the ledge for 15-seconds before being returned to the restraining cage for the inter-trial interval; following which the <u>same</u> trial was re-run until a 'correct' response was produced by the subject. If during these correction trials the subject became 'fixated' on one side (i.e. five such consecutive responses) then the subject was forced to respond to the other side by blocking the 'incorrect' arm of the jumping platform with a large, immovable block of wood for one or two trials. Such a correction procedure (when necessary), ensured that the subject was used to an occasional non-reward/

reward for responding, and also equally familiar with both sides of the apparatus before discrimination training began. Twenty such trials were given per day, for this four day period.

Throughout pretraining, white noise was gradually introduced until by Day five, it was at the maximum experimental level of approximately 60 db.

<u>Procedure and Design</u>

Following pretraining, simultaneous discrimination training was begun, adopting a procedure identical to the last four days of pretraining (outlined above) with the exception that Stimulus four and five were used in place of the unpainted hardboard doors.

Subjects were randomly assigned to one of two groups. Group H was trained with Stimulus four as the positive stimulus and Stimulus five as the negative one; and Group V was trained with Stimulus five as the positive stimulus and Stimulus four as the negative one (see Figure 4-4). Four subjects were assigned to each group. Twenty trials were given per day with the correction procedure, where appropriate - up to a criterion of acquisition of eighteen correct responses out of twenty consecutive trials. If at the end of the daily session of twenty trials, the subject required only two more correct responses to reach criterion, then two more trials were given.

Equivalence testing was begun on the day after criterion was reached on the original discrimination problem. Each subject was tested with six equivalence pairs, which are displayed in Figure 5 (4). Each day's testing began with four training trials (i.e. the original discrimination/

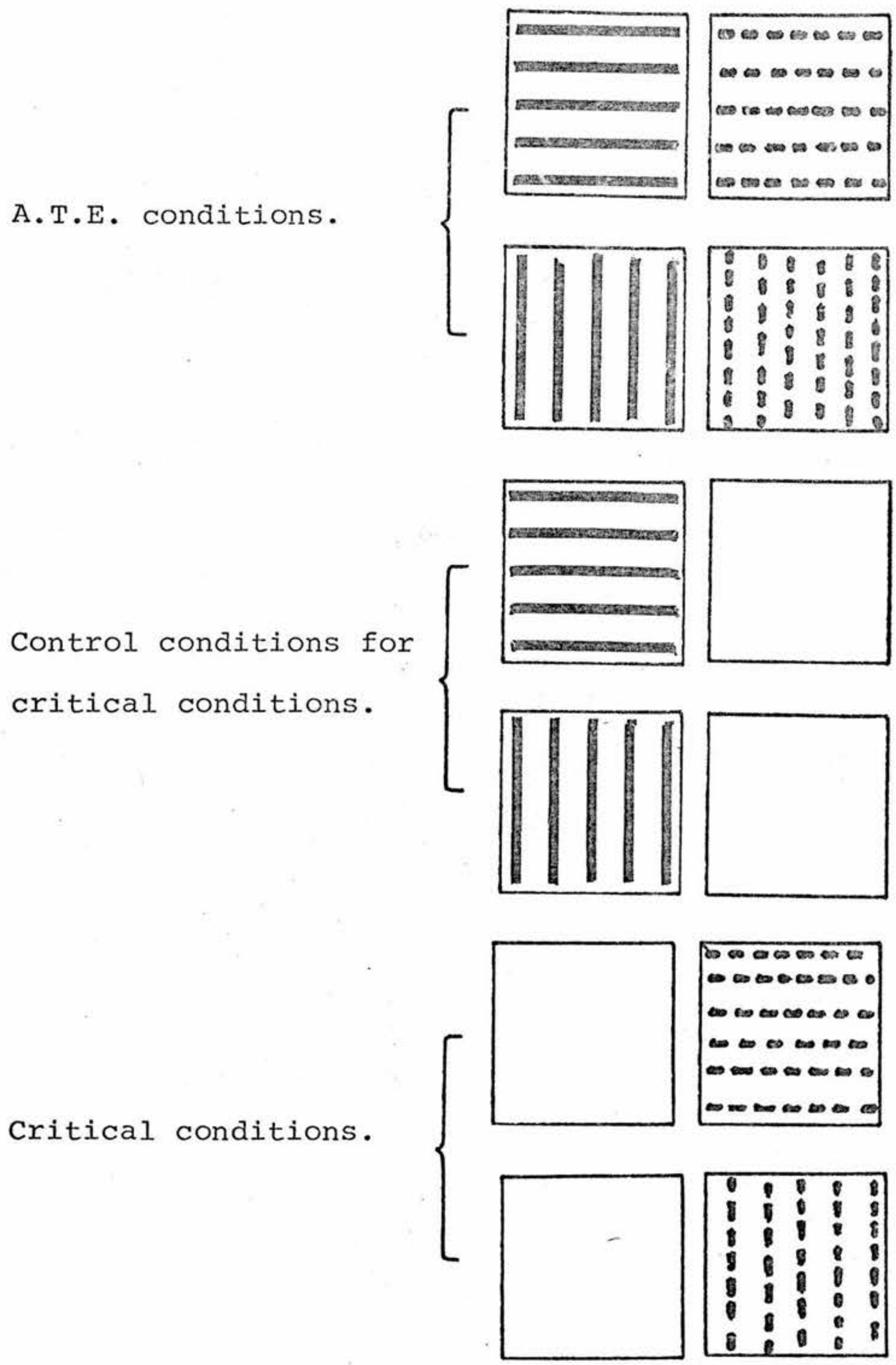


Figure 5 (4). The 6 pairs of stimuli used in the equivalence testing trials of Experiment 1 (4).

Note: The patterns are white on a black background.

discrimination problem, during which time differential reward was in operation). Subjects were allowed to make no more than one error during these four trials, or they were returned to the original discrimination problem and required to re-attain criterion of acquisition - otherwise, they were given a further ten trials, five of which were equivalence testing trials with an equivalence pair during which either response that the subject could make was rewarded and five of which were differentially rewarded training trials. These ten trials were given in a predetermined random sequence. Should more than one error occur during the nine training trials per day, then the equivalence results of that day were to be discarded and the subject returned to the original training schedule until criterion was reached again.

The four subjects of each group received the six equivalence pairs in different orders. The four orders of presentation were determined using four rows of a 6 x 6 Latin Square - and one subject from each group was assigned to each of the chosen rows (i.e. the two groups were treated in an identical manner during the equivalence testing sessions, with the exception of the reward contingencies during the interpolated training trials).

RESULTS

Acquisition Performance

The performance of both groups was compared up to criterion. The rate of learning was the same for both groups in terms of trials to criterion/

criterion (t-test for independent measures - $t = 0.46$; $df = 6$; $p > 0.7$ for a two-tail test) and errors to criterion (t-test for independent measures - $t = 1.99$; $df = 6$; $p > 0.1$ for a two-tail test). Table 1 (4) records the performance of both groups for these measures.

Equivalence Testing Performance

The performance of the two groups on the equivalence pairs is shown in Figure 6 (4). The table of Figure 6 (4) displays the distribution of choices for each subject between the two stimuli of each equivalence pair. Visual inspection of the table unambiguously shows that in the first two columns (conditions that have been run in previous experiments - Krechevsky, 1938 and Dodwell, 1970) and in the third and fourth columns, subjects tend to prefer one stimulus of the equivalence pair to the other. In fact, the direction of the distribution of preferences in each of these conditions (represented by the first four columns of Figure 6-4) for all the subjects is consistent, with the exception of one result (i.e. one result out of thirty-two). In the last two columns, however, (representing the critical conditions suggested as being important in the introduction) subjects tend not to show any consistent choice behaviour.

One-tail probabilities were derived using the binomial test (where $p = q = \frac{1}{2}$) for each subject's score under each condition of equivalence testing (see Table 2-4). A method of combining these individual probabilities under each condition was used (Winer, 1962, page 43-44), seperately, on the scores of the first four conditions (i.e. the first four columns of Figure 6-4), to the effect that there is a significant choice/

Group	Subject	Trials	Errors
V	1	70	46
	2	240	94
	3	286	151
	4	190	71
	Mean	196	90
H	5	200	72
	6	271	117
	7	190	73
	8	217	102
	Mean	219	91

Table 1 (4). The acquisition performance of Group V and Group H for the discrimination training of Experiment 1(4).

Note: The scores do not include the criterion-run.

Group	Training	Stimulus Pairs: Equivalence											
V	+ -												
S 1		7	3	2	8	10	0	5	5	6	4	4	6
S 2		9	1	0	10	9	1	0	10	10	0	9	1
S 3		9	1	2	8	8	2	4	6	7	3	4	6
S 4		10	0	1	9	8	2	0	10	4	6	10	0
Mean		9	1	1	9	9	1	2	8	7	3	7	3
H	+ -												
S 5		10	0	3	7	10	0	3	7	4	6	5	5
S 6		9	1	2	8	9	1	1	9	5	5	5	5
S 7		10	0	1	9	10	0	1	9	4	6	0	10
S 8		10	0	2	8	7	3	0	10	4	6	3	7
Mean		10	0	2	8	9	1	1	9	4	6	3	7
Joint mean		9	1	2	8	9	1	2	8	6	4	5	5

Figure 6 (4). The distribution of choices for each Subject on each of the equivalence testing pairs of Experiment 1 (4).

Note: The 'means' are rounded off to the nearest integer.

choice bias under these conditions (for each condition Chi-square 58; df = 8; $p < 0.001$). This method could not be applied to the remaining two (critical) conditions since differences between individual subject's choice scores occur in both directions, violating one of the requirements of this method. However, applying the binomial test to the sum of the choice responses derived from each of the two critical conditions showed overall responding to be at chance in both cases ($p > 0.3$).

An interesting result is derived from the critical conditions in that, although the subjects tend to respond at chance levels in these conditions, significantly more errors are made when the horizontal matrix is paired with the blank, than when the vertical matrix is thus paired (Wilcoxon matched-pairs signed-ranks test - $T = 0$; $n = 6$; $p < 0.05$ for a two-tail test). In fact, no subject produces scores which go against this observation (although one subject from each group makes an equal number of errors under each of these two conditions).

DISCUSSION

The albino rats of Experiment 1 (4) learned the discrimination in a similar number of trials and errors as did Krechevsky's pigmented rats (Dodwell does not report his acquisition data), and as in previous experiments the performance of the two groups in acquiring the discrimination was symmetrical - suggesting that the procedures used in all these experiments were equivalent. This is strengthened by the fact that every subject of Experiment 1 (4) showed the complete A.T.E. as described by Dodwell. What is interesting, however, is the fact that/

that in the critical conditions of equivalence testing (where a matrix is paired with a 'blank' stimulus) discrimination behaviour breaks down. The reason for this could be that these critical conditions represent a great divergence from the training problem and are, as a result of this, generally disruptive of behaviour. However, it is unlikely that this is the explanation, since in those conditions where a continuous version of the training stimulus is paired with a 'blank' stimulus, the disruptive effect is slight and the discrimination behaviour is maintained - and yet both stimuli in these conditions represent departures from the original problem.

It seems clear that in order to organize the matrices used in these experiments, it is not sufficient to present the individual matrix, itself, without a comparison stimulus (in this case, another matrix) - even when each subject has demonstrated that he is able to carry out such an organization in order to solve the discrimination training problem, and carry this organization into the interpolated training trials of the equivalence testing sessions. In this sense, Experiment 1 (4) is a more stringent test of the Gestalt position with respect to spontaneous organization of matrices, and is consistent with Hypothesis 2 and 4. An experiment is required to distinguish between these two explanations, and such is Experiment 2 (4), which follows.

EXPERIMENT 2 (4)

INTRODUCTION

In order to distinguish between Hypothesis 2 and 4, it is necessary to teach subjects a horizontal and vertical set which does not involve the proximity principle and then, in equivalence tests, to test whether such horizontality and verticality is detected within the matrices that are presented. That is, subjects never get to experience the proximity stimuli until the equivalence tests, themselves. Good positive transfer in the equivalence testing when matrix stimuli are presented in pairs (i.e. each one having an appropriate comparison stimulus) would be consistent with Hypothesis 2; whereas no such transfer would suggest that spontaneous organization of the matrix under these conditions of testing is weak or absent and would be more consistent with Hypothesis 4 than 2 (although not necessarily confirm it).

Squirrel monkeys were to be used as subjects in Experiment 2 (4) - the results of experiments, thus far (i.e. Krechevsky and Dodwell), suggest that there is no reason not to regard their performance, with regard to the purposes of the current experiments, as being equivalent. The horizontal and vertical set can be appropriately taught using horizontal and vertical striations. Equivalence testing would be similar to Experiment 1 (4), but, of course, the A.T.E. could not be tested for. The use of squirrel monkey and the apparatus that they would be scheduled to use (the W.G.T.A.) does produce one problem. In Dodwell et al's (1970) experiment in which squirrel monkeys were used/

used, the stimuli were presented unambiguously in the animal's vertical plane at head height and within arm's length of the restrained subjects (apparatus is described by Thompson, Seal and Bloom, 1959). In Experiment 2 (4), the stimuli must be presented in some way on the W.G.T.A.'s tray (desirable, since subjects were skilled in using this piece of apparatus), and since the subject tends to look down at the tray at an angle of 45 degrees (approximately, and very variable), there is some doubt as to which plane to use for the presentation of the stimuli. For this reason, it was decided to present every stimuli in <u>both</u> the vertical and horizontal plane (with respect to gravity). In the vertical plane, the stimulus base would be the gravitational base; and in the horizontal plane, it would be that edge of the stimulus nearest to the subject.

METHOD

<u>Subjects</u>

Six male, common squirrel monkeys (<u>Saimiri Sciureus</u>) served as subjects. They were experimentally sophisticated having served as subjects in the experiments described in Chapter 2 and 3. The subjects were maintained under the same conditions as were detailed in these experiments.

<u>Apparatus</u>

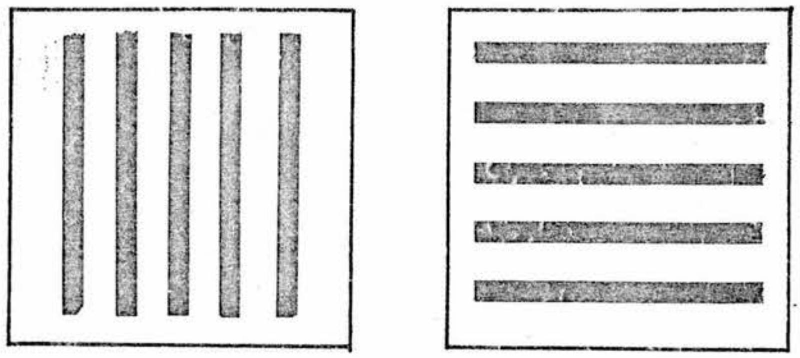
The same Wisconsin General Testing Apparatus, painted matt mid-grey, as was used in the experiments of Chapter 2 and 3, was used in this experiment. The stimulus-tray used was the two-foodwell variety, the foodwells/

foodwells being positioned 6" apart. The stimulus-tray was painted matt white.

Stimuli

Two sets of stimuli were used in this experiment. Set one consisted of $3\frac{1}{2}$" x $3\frac{1}{2}$" matt white plaques upon which were painted five matt black stripes $\frac{1}{4}$" wide, $2\frac{1}{4}$" long and $\frac{1}{4}$" apart - producing a $\frac{5}{8}$" wide matt white border around the stimulus. Stimulus H had its stripes oriented horizontally and Stimulus V had them oriented vertically (see Figure 7-4). Set two consisted of $3\frac{5}{8}$" x $3\frac{5}{8}$" matt white plaques whose five matt black stripes were 3/16" wide, 3 5/16" long and $\frac{5}{8}$" apart. The ensuing border was minimal (approximately 1/16"). Stimulus H had its stripes oriented horizontally, and Stimulus V had its stripes oriented vertically. A discontinuous version of the continuous stimuli of Set two was made by replacing the 3/16" wide stripes with matt black squares (3/16" x 3/16") 3/16" apart. They were arranged in register with the stripes of the continuous stimuli, i.e. the five lines of nine squares were positioned $\frac{5}{8}$" apart. Stimulus HD was oriented horizontally and Stimulus VD was oriented vertically. A further 'blank' stimulus (Stimulus B) was used, which consisted of a $3\frac{5}{8}$" x $3\frac{5}{8}$" matt white plaque with no markings (see Figure 8-4).

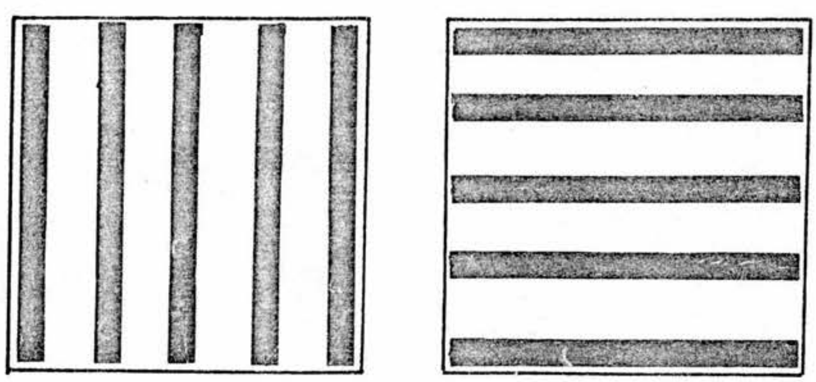
Two versions of Set one and Set two stimuli were made - they were identical in every way except that one was made to lie flat on the surface of the stimulus-tray and the other was made to stand at right angles to this surface and facing the cage from which the subjects responded. The former were called the Flat stimuli and took its base as/



Stimulus V. Stimulus H.

Figure 7 (4). Set 1 stimuli of Experiment 2 (4).

Note: The diagram above is approximately half-size.



Stimulus V. Stimulus H.

Figure 8 (4). Set 2 stimuli of Experiment 2 (4).

Note: The diagram above is approximately half-size.

as being that edge of the plaque, lying on the surface of the tray, nearest to the subject; the latter were called the Upright stimuli, having a normal gravitational base (see Figure 9-4).

Four identical exemplars of each stimulus were constructed and randomly used from trial to trial to prevent subjects using features specific to any one plaque to solve the discriminations, rather than the stimulus patterns, themselves.

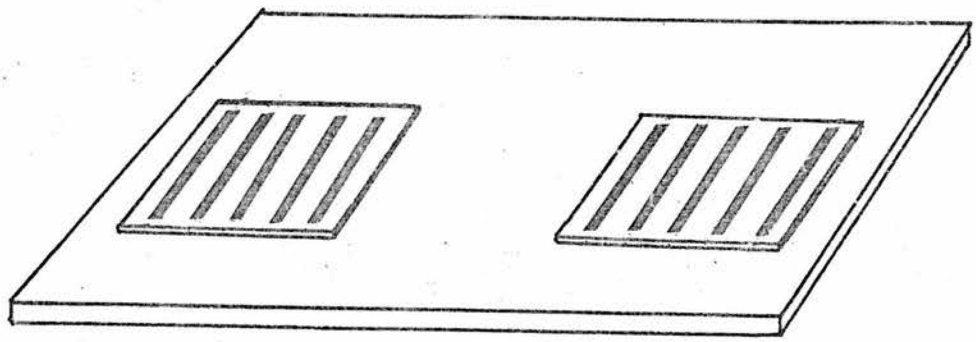
Procedure and Design

Pretraining sessions were, of course, not required since subjects were experienced with both the apparatus and the presentation of stimulus plaques in both the horizontal and vertical plane. The general procedure adopted was identical with that described in Experiment 1 (2) and was used in all the experiments involving the W.G.T.A. and squirrel monkeys, reported here.

All subjects were taught to discriminate between horizontal and vertical stripes (i.e. between Stimulus H and Stimulus V). The stimulus pair to be discriminated were presented in either the Upright condition (at right angles to the tray surface) or the Flat condition (flat on the surface of the tray), in alternating blocks of five trials. The criterion of acquisition for both the U and F conditions was eighteen correct responses out of twenty consecutive trials and a correction procedure was employed. Three subjects had responses to Stimulus H rewarded (Group H) and three to Stimulus V (Group V).

Both groups were initially trained with the two stimuli from Set one. A period of several weeks was interposed between their reaching criterion/

The Flat Condition - F.



The Upright Condition - U.

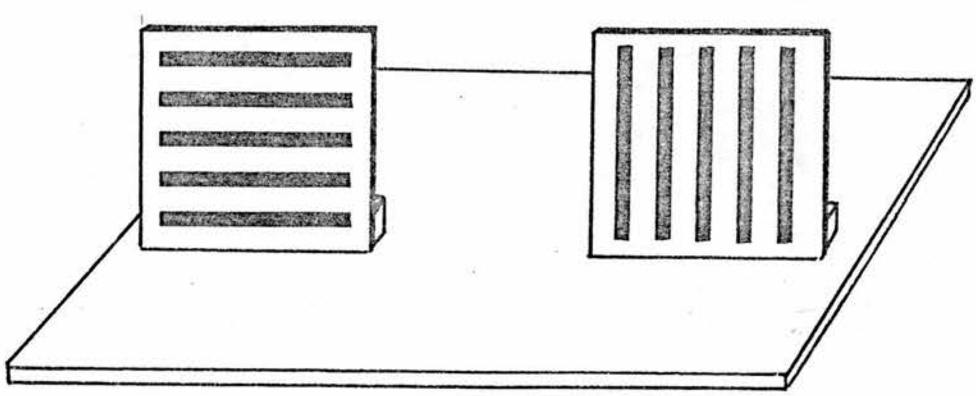


Figure 9 (4). An illustration of the Flat and Upright conditions of stimulus presentation used in Experiment 2 (4).

Note: The stimulus plaques on the stimulus tray as seen by the subjects.

criterion on Set one stimuli, and their being retrained on the corresponding stimuli of Set two (whilst still retaining their group identity). After criterion using Set two stimuli had been attained, ten equivalence testing sessions were carried out - one session per equivalence stimulus pair.

Each daily equivalence session began with ten differentially rewarded training trials (using the re-acquisition stimuli of Set two) during which the subject was required to make no more than one error to permit him to continue into equivalence testing, that day. Twenty trials were then given, consisting of ten-non-differentially rewarded equivalence trials using a predetermined pair of equivalence stimuli and ten differentially rewarded training trials randomly interspersed among the equivalence trials. If the subject made more than one error during these interpolated training trials, the equivalence scores for that session were discarded and he was retrained to criterion before being allowed to continue. More than one error occurring during the first ten trials of that day also required the subject to be retrained to criterion. Each subject was given five different equivalence stimulus pairs (see Figure 10-4), in both the U and F condition. Only one equivalence stimulus pair in one condition (i.e. U or F) was presented in one session; and each subject was given all equivalence stimulus pairs in both conditions. Thus, each subject received ten equivalence testing sessions - one per day. The order of presentation counterbalanced across subjects of each group - and for each order of presentation received by a subject of Group H, a subject of Group V received the same order. The twenty training trials of each session were/

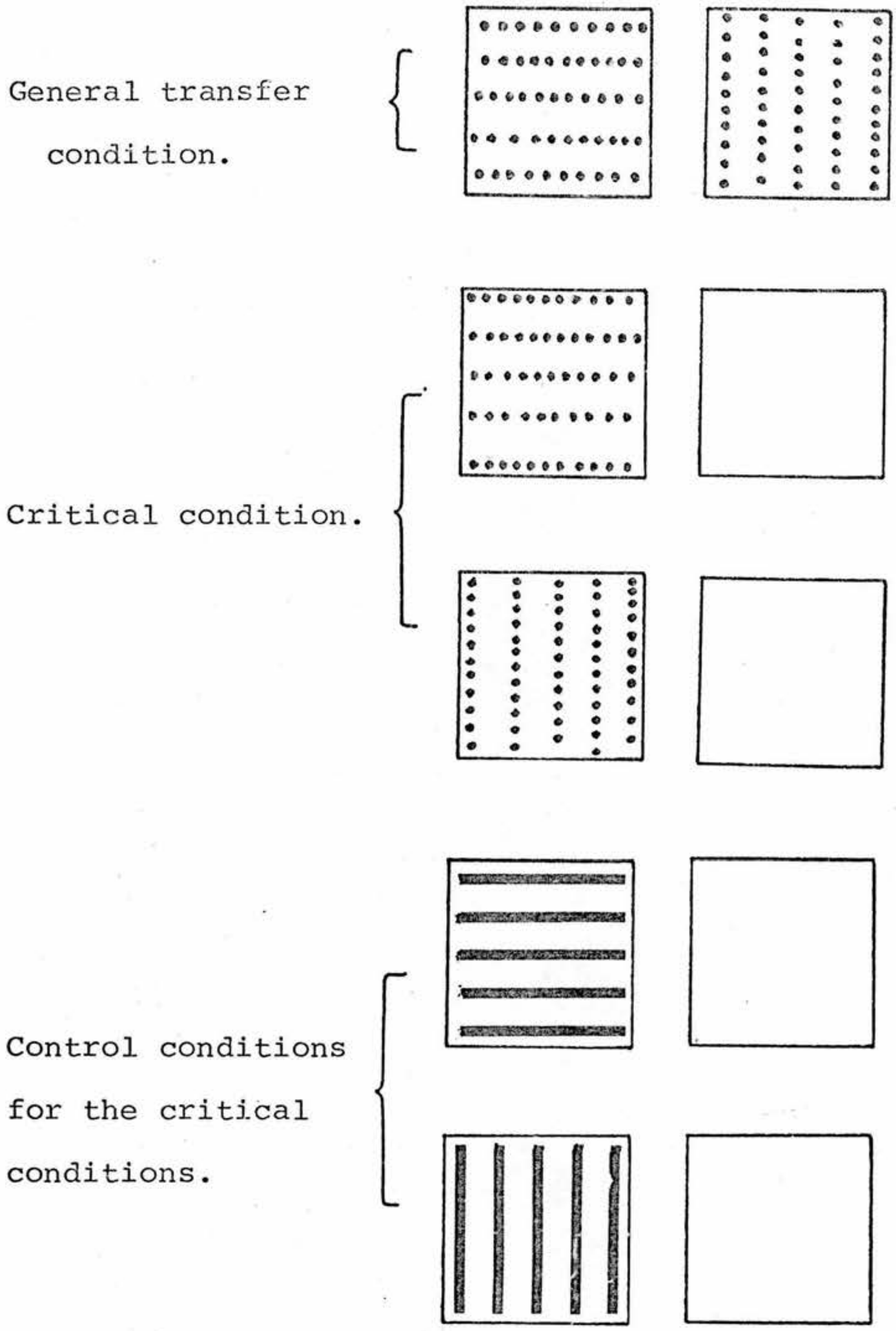


Figure 10 (4). The 5 pairs of stimuli used in the equivalence testing trials of Experiment 2 (4).

were of the same condition (i.e. either U or F) as the equivalence stimulus pair assigned to that experimental session.

RESULTS

Acquisition Performance

The acquisition performance of the two groups is displayed in Table 3 (4) for the Set one stimuli and Table 4 (4) for the Set two stimuli. The difference between the total number of errors (i.e. condition U and F combined) to criterion with the Set One stimuli made by the subjects of the two groups was not significant, (t-test for independent measures - $t = 8.4$; $df = 1$; $p > 0.1$ for a two-tail test). Combining the scores for Group V and H, significantly more errors were made in condition U than if F, (t-test for related measures - $t = 3.47$; $df = 5$; $p < 0.01$ for a one-tail test) - in fact, every subject made more errors in the Upright condition than in the Flat condition. The results of Experiment (2) permit one-tail or directional predictions to be made in the latter comparison. Similar results were obtained for the re-acquisition of the discrimination with the stimuli of Set two. In terms of total errors to criterion (i.e. with the U and F condition combined), Group H was not significantly different from Group V (t-test for independent measures - $t = 8.5$; $df = 1$; $p > 0.1$ for a two-tail test) - and combining the scores of Groups V and H, as before, significantly more errors were made in condition U than condition F, (t-test for related measures - $t = 2.7$; $df = 5$; $p < 0.05$ for a one-tail test).

Equivalence/

Group	Subject	Set 1		Set 2	
		Upright	Flat	Upright	Flat
H	1	84	82	30	0
	2	39	29	6	0
	3	56	33	6	4
	Mean	59	48	14	4
V	4	80	57	10	6
	5	30	23	8	2
	6	84	53	12	8
	Mean	65	44	10	5

Table 3 & 4 (4), combined. The acquisition performance of Group H and Group V for the discrimination training of Experiment 2 (4), with both Set 1 and Set 2 stimuli.

Note: The scores do not include the criterion-run.

Equivalence Testing Performance

For the performance of each subject on each of the ten equivalence pairs, Figure 11 (4) can be inspected. Each column of this figure contains the corresponding equivalence testing version of the initial discrimination pair - in terms of the orientation of the positive and negative stimulus, as in Experiment 1 (4). For Group V and H, the scores are, thus, combined. Visual inspection of Figure 11 (4) indicates that a choice bias tends to be present in the conditions represented by the columns 1, 2, 7, 8 and perhaps 9, and 10. Significant choice bias in terms of column totals is shown by columns 1, 2, 7, 8 and 10. In only these conditions is the direction of the preference for each subject totally consistent towards the representative of the previous positive stimulus, or away from the representative of the previous negative stimulus. Applying the method of combining one-tail probabilities derived from each subject's performance on each of the equivalence stimulus pairs where there is a consistent direction of choice (Winer, 1962, as in Experiment 1-4) shows that in the conditions represented by these columns, a significant choice bias exists (Chi-square = 54; df = 6; $p < 0.001$ for columns 1, 2, 8 and 10). As in Experiment 1 (4), applying the binomial test to the sums of choice responses derived from each of the critical conditions (i.e. columns 3, 4, 5 and 6) showed overall responding to be at chance ($p > 0.4$), as well as the condition represented by column 9. This discrepant finding (i.e. column 9) is due to the performance of Subjects two and three in only condition U - their performance in condition F is consistent with the results as a/

Group	Training	Equivalence																			
H	+ −	U		F		U		F		U		F		U		F		U		F	
S 1		8	2	10	0	7	3	5	5	4	6	6	4	9	1	10	0	1	9	1	9
S 2		7	3	9	1	1	9	8	2	6	4	8	2	8	2	10	0	8	2	1	9
S 3		10	0	8	2	6	4	3	7	2	8	3	7	8	2	9	1	8	2	1	9
Mean		8	2	9	1	5	5	5	5	4	6	6	4	8	2	10	0	6	4	1	9
V	+ −	U		F		U		F		U		F		U		F		U		F	
S 4		8	2	9	1	6	4	9	1	6	4	6	4	10	0	10	0	2	8	0	10
S 5		8	2	8	2	3	7	3	7	8	2	4	6	9	1	10	0	1	9	3	7
S 6		10	0	8	2	8	2	6	4	7	3	6	4	10	0	8	2	2	8	2	8
Mean		9	1	8	2	6	4	7	3	7	3	5	5	10	0	9	1	2	8	2	8
Joint mean		9	1	9	1	5	5	6	4	5	5	5	5	9	1	9	1	4	6	1	9

Stimulus Pairs

Figure 11 (4). The distibution of choices for each subject on each of the equivalence testing pairs of Experiment 2 (4).

Note: U = Upright condition; F = Flat condition. The 'means' are rounded off to the nearest integer.

a whole.

As was the case in Experiment 1 (4), more errors were made in the critical conditions when the blank stimulus was paired with the horizontal matrix than with the vertical matrix, even though the overall performance of the subjects in these conditions was at chance. However, in this experiment, the difference just failed to reach significance in condition U (t-test for related measures - $t = 2.5$; $df = 5$; $p > 0.1$ for a two-tail test), and was not significant in condition F (t-test for related measures - $t = 1.7$; $df = 5$; $p > 0.1$ for a two-tail test).

DISCUSSION

The acquisition scores indicate that the subjects find the discrimination in the vertical plane more difficult than in the horizontal plane - for both Set one and Set two stimuli. However, as Experiment 9 (2) has indicated, it seems likely that this has little to do with the planes, themselves, but rather the other surfaces that occur in the planes along with the stimuli. The stimuli in Condition F lie upon the white surface of the stimulus tray and this white surface would appear to be continuous with the white background of the plaque upon which the stimulus striations occur. The effect is to make the striations particularly prominent on the surface of the tray, since there is little else to 'distract the subject's attention' on that surface. In Condition U, however, the situation is different in that the white background of the stimulus plaque is at right angles to the tray, and has as its backdrop (from the subject's position of view) part/

part of the stimulus tray (white), part of the stimulus arena and its walls (grey) and part of the limited-vision screen (very dark) - i.e. a collection of colours and contours. Further, since the subject's head is continually moving (the subject is unrestrained), motion parallax would help to segregate the stimulus plaque from the background, and as Warren (personal communication) has shown, it is the outer edges of whatever is at the stimulus location that tends to be the subject of attention. Clearly, this would be to the detriment of Condition U, since the outside edges of both stimuli are identical in this area. However, that the discrimination is eventually learned does indicate that the outer edges do not totally capture the attention.

In the equivalence testing, there was strong positive transfer from the continuous training stimuli to the discontinuous versions when presented in pairs. Clearly, the subjects must be detecting in the paired matrices (represented by columns 1 and 2 of Figure 11-4) the set that had been given in the training phase. The expectations outlined in the Introduction of Experiment 2 (4) have been confirmed. Further, this set is detected when one of the continuous training pair is paired with a 'blank' stimulus (columns 7, 8, 9, 10 of Figure 11-4) indicating that the mere presence of a 'blank' is not disruptive, and confirming what was found in Experiment 1 (4). However, when the discontinuous version of one of the training stimuli is, thus, paired, no set is detected since choice behaviour is disrupted. These results, taken as a whole, are consistent with those of Experiment 1 (4), even though a different type of training stimulus was used. Apart from confirming the conclusions of the previous experiment - that the matrix/

matrix is only organized when an appropriate comparison stimulus is present - this experiment indicates that this organization is a relatively spontaneous event (a perceptual-learning effect). Hypothesis 2 is, thus, favoured over Hypothesis 4. Krechevsky's explanation of his discrepant finding (i.e. the 'easy' condition) is, clearly, inconsistent with the results of the current experiment, and Dodwell's model is, further, found wanting.

E X P E R I M E N T 3 (4)

INTRODUCTION

The results of both Experiment 1 (4) and 2 (4) have indicated that in order to polarize a matrix of similar elements (physically polarized in a vertical or a horizontal direction) under the conditions of this experiment, it must be <u>related</u> to a similar matrix, which is physically polarized in the opposing direction. The conclusion that the relationship between the two matrices is important is reached since, in the critical conditions of these experiments in which discrimination behaviour breaks down, no such relationship or comparison can occur. The maintenance of discrimination behaviour in the conditions of Experiment 1 (4) where the continuous version of the matrix is presented with the inappropriate comparison stimulus (i.e. the 'blank'), suggest that it is not the mere <u>presence</u> of the novel 'blank' stimulus that is causing the breakdown of choice behaviour, but the <u>absence</u> of the 'opposite' matrix. However, since the performance of subjects on these critical conditions is of major importance to the current investigation, the decision was taken to introduce further critical conditions in which the stimulus pair used resembled as closely as possible the two-matrix stimulus pair of the training stimuli of Experiment 1 (4), and yet still contained an 'inappropriate' comparison stimulus. Stimuli that have, thus far, been demonstrated as being 'inappropriate', have been the discontinuous cross stimulus of Krechevsky (see Figure 2b (4), Stimulus X) and the 'blank' stimulus of/

of the current series of experiments. Both of these stimuli lack any index of direction common to either the 'horizontal' or 'vertical' matrices used in these experiments. A third stimulus which would fit into this category, in not offering any horizontal or vertical directional information, and which would greatly resemble the training matrices, would be a 'regular' matrix in which the centre-to-centre ratio of the elements was 1 : 1. Experiment 3 (4) contains such a critical condition, as well as the critical conditions used in the previous two experiments, for comparison purposes. If it is the case that a 'regular' matrix is an inappropriate comparison stimulus, then, it is postulated that there should be no difference between these two types of critical condition, i.e. critical conditions containing a 'regular' matrix should produce chance responding, even though the paired discriminanda closely resemble the training stimuli and, therefore, cannot be disruptive in the 'novelty' sense.

In Experiments 1 (4) and 2 (4), the responses of subjects in equivalence tests were non-differentially rewarded. However, Warren and McGonigle (1969) have demonstrated that such equivalence tests can be an in-sensitive index of discrimination set transfer and that, often, further (transfer) trials with appropriate differential reward can detect discrimination sets which have been missed by equivalence tests. (A useful nomenclature to adopt: equivalence tests with non-differential reward and transfer tests with differential reward). If this is the case, then a wise precaution would be to run many more trials than the ten per experiment used for the critical conditions, thus far, and to differentially reward the subjects responses in a way appropriate/

appropriate to the discrimination training phase. Experiment 3 (4) uses such a procedure.

In testing between so-called perceptual and perceptual-learning explanations of the differential organization of the matrices depending upon what they are related to, and to ensure that subjects had at the end of discrimination training, indeed, a vertical-horizontal set, squirrel monkeys of Experiment 2 (4) were trained with horizontal and vertical striations rather than the corresponding matrices - unlike the rats of Experiment 1 (4). The subjects (rats) of the current experiment, therefore, were to be trained under the same conditions as the squirrel monkeys, and therefore, the transfer conditions of the current experiment would serve as a further test between perceptual and perceptual-learning explanations of matrix-organization, previously outlined - but this time with a different species in a different type of apparatus using a different procedure.

Experiment 3 (4), therefore, differs from its corresponding experiment (Experiment 1-4) in that further critical tests are used, the transfer conditions are run with differential reward procedures and an increase in the number of trials, and the training phase of the experiment utilises horizontal and vertical striations to teach the discrimination set. A further difference was incorporated in the current experiment to test, more stringently, the robustness of the major finding. In the two previous experiments, the matrices have had centre-to-centre ratios standardizes at approximately 2 : 1 (those experiments reported by Krechevsky and Dodwell, too). In the current experiment, a whole range of ratios (from 3 : 1 to 1 : 2 : 1) are used in a repeated measures/

measures design, enabling a more detailed and extensive comparison between the different transfer conditions to be made, (the details of this repeated measures design, and the way in which more detailed comparisons can be made are left until the appropriate part of the next section).

In Experiment 1 (4), rats found it more easy to polarize the physically vertical matrices than the horizontal ones, when related to a 'blank' stimulus; and similar (though less strong) results were found with the monkeys of Experiment 2 (4). These results were obtained, however, with only a small number of trials, but they were interesting in that they were in close agreement with what has been found with human adults (but with single matrices). Bell and Bevan (1968, Experiment 1) has demonstrated that there is a predilection to organize ambiguous dot matrices (i.e. with centre-to-centre ratios of 1 : 1) into vertically polarized matrices than horizontally polarized ones; and the present author has, since, confirmed these results (a pilot study, not to be reported here). The repeated measures design of the current experiment allows, as a bonus, this observation to be exhaustively tested in rats.

METHOD

Subjects

Eight experimentally-naive, male hooded rats served as subjects (purchased from the Rowett Institute, Aberdeen, Scotland). At the onset of pretraining, they were approximately ninety days of age. Conditions of maintenance were identical to those of Experiment 1 (4).

Apparatus/

Apparatus

A modified Lashley Jumping Stand, identical to the one used in Experiment 1 (4), was constructed from $\frac{1}{2}$" chipboard and painted matt mid-grey. The doors of the apparatus were made of hardboard, and also painted matt mid-grey. Lighting and white-noise level were similar to those of before, (i.e. Experiment 1-4).

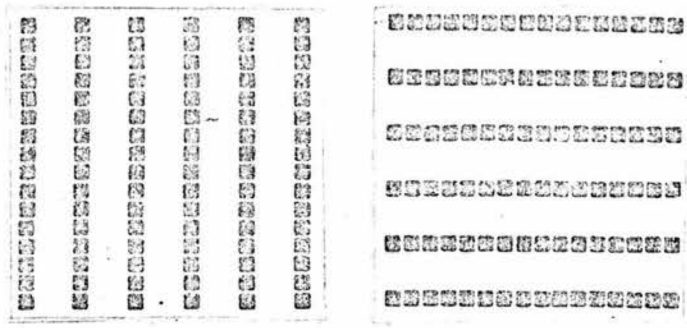
Stimuli

Stimulus patterns were constructed from black Letraset transfers on the matt mid-grey background of the doors.

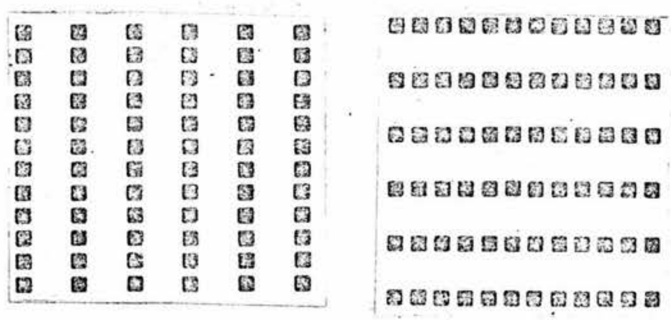
The training stimuli were equivalent to those of Experiment 2 (4), rather than Experiment 1 (4) - they consisted of vertical or horizontal stripes which were parallel and equally spaced apart on that portion of the door of the apparatus which was coincident with the 6" x 6" door aperture. The stripes were six in number, $\frac{1}{4}$" wide and 6" long.

The transfer stimuli consisted of matrices of $\frac{1}{4}$" squares (black Letraset transfers) arranged in a similar way to Stimulus four and five of Experiment 1 (4) and Stimulus HD and VD of Experiment 2 (4). In Experiment 1 (4) and 2 (4), the elements of the matrices were arranged with a centre-to-centre ratio of 2 : 1 and 1·8 : 1, respectively. In this experiment, the transfer stimuli were constructed with nine different matrices, each having a different centre-to-centre ratio. These ranged from 3 : 1 to 1·2 : 1 and the values are recorded, along with the matrices, in Figure 12 (4). Three further transfer stimuli were constructed (see, also Figure 12 - 4) - a 'blank' stimulus was made as in the two previous experiments (i.e. consisting, solely, of/

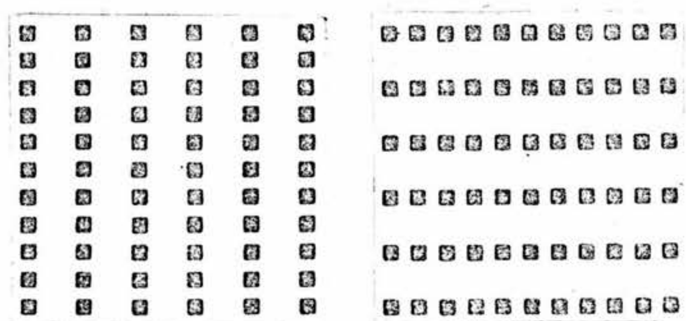
Stage 1. 3:1



Stage 2. 2·4:1



Stage 3. 2:1



Stage 4. 1·75:1

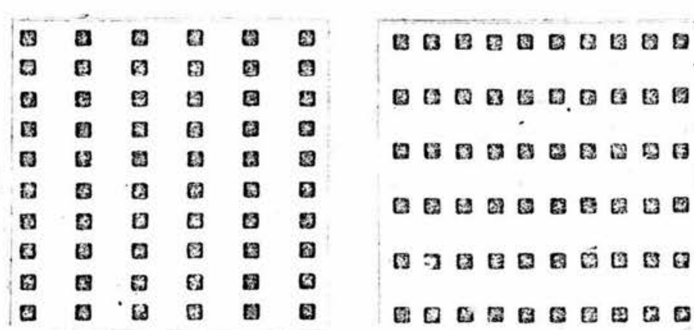
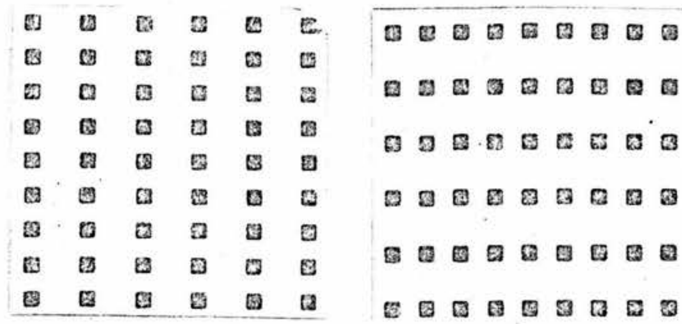
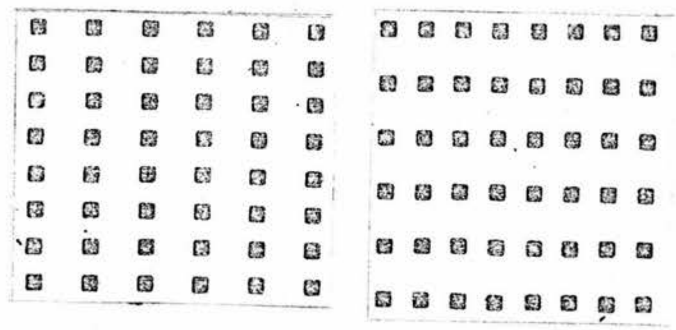


Figure 12 (4). The paired transfer stimuli used in Condition A for each of the 9 Stages, and the 2 'regular' matrices used with the appropriate stimulus of the pairs of Condition A, for Condition C. (continued...)

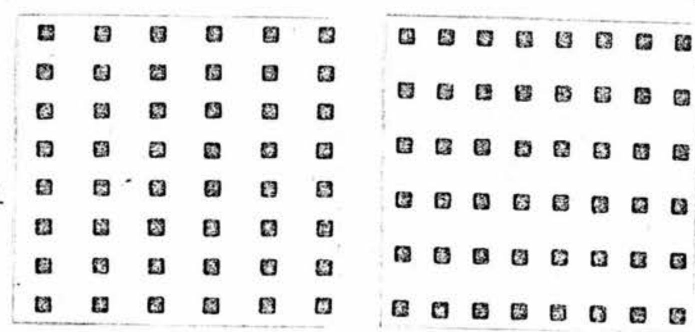
Stage 5. 1·6:1



Stage 6. 1·5:1



Stage 7. 1·4:1



Stage 8. 1·3:1

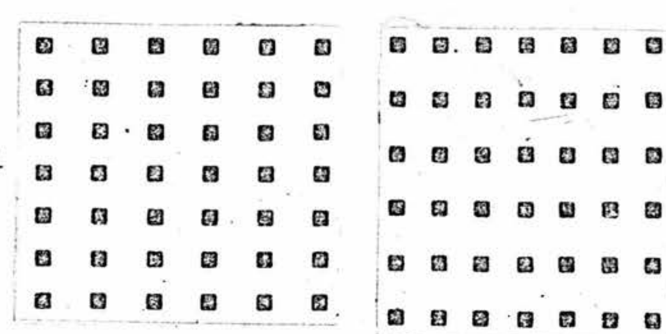
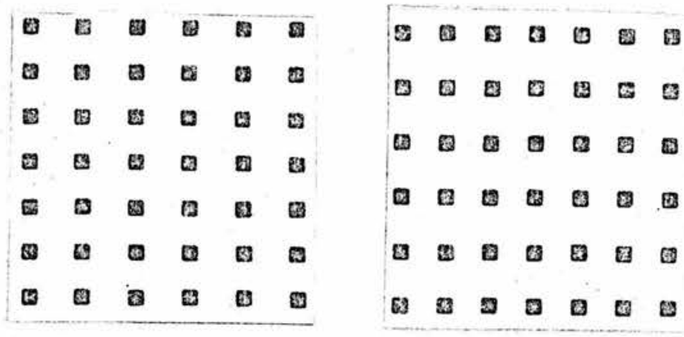
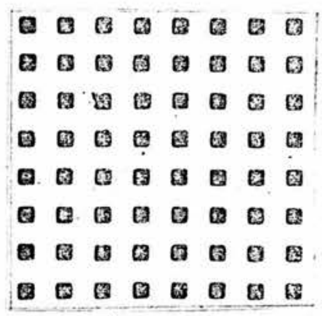


Figure 12 (4). See title on previous page. (continued..)

Notes: The stimuli are exact reproductions of the stimuli, reduced to ¼-size.

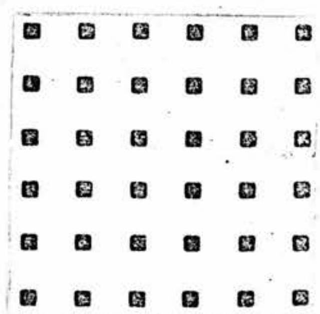
Stage 9. 1·2:1





Regular matrix 1. 1:1

(Used in Condition C,
for Stages 1-4, incl.)



Regular matrix 2. 1:1

(Used in Condition C,
for Stages 5-9, incl.)

Figure 12 (4). See previous 2 pages for title and notes.

of the mid-grey background painted on the doors), and two so-called 'regular' matrices. These two stimuli were made with centre-to-centre ratios of 1 : 1, one matrix was six elements x six elements and the other eight x eight.

As was the case in Experiment 1 (4) and 2 (4), a number of identical versions of each stimulus was constructed, and identical versions of each stimulus pattern were randomly interchanged from trial to trial.

Procedure and Design

In general, the pretraining and training procedures were the same as in Experiment 1 (4). However, a correct response was rewarded by twenty seconds access to food, and an incorrect response resulted in a twenty second restraining period on the door-ledge. The inter-trial interval was increased to thirty seconds.

As in previous experiments, the subjects were divided into two groups of four subjects. Group H was trained with the horizontally striped stimulus of the training pair as positive, and Group V with the vertically striped stimulus positive. Twenty trials per day were given with a correction procedure whenever appropriate. The criterion of acquisition was, conventionally, taken as eighteen correct responses out of twenty consecutive trials. Transfer testing was begun on the day following that on which criterion was met.

The transfer section of this experiment consisted of eight stages, each stage having sixty trials equally spread over two days. The sixty trials, representing two days of testing, consisted of thirty training trials (the same discrimination problem that the subjects had learned/

learned in the acquisition section) and thirty randomly interpolated transfer testing trials, using the stimuli described in Figure 12 (4). There were four conditions of stimulus presentation. Condition T had the original discrimination pair of stimuli; Condition A had both vertically and horizontally organized matrices (both with the same centre-to-centre ratios) presented together; Condition B had the blank stimulus paired with either the horizontally organized or the vertically organized matrix (which matrix was used was determined by a predetermined randomly alternating sequence); Condition C was identical to Condition B, except for the fact that one of the two regular matrices was used in place of the blank. Figure 13 (4) displays the four different conditions. Each stage consisted of thirty trials of Condition T, ten trial of Condition A, ten trials of Condition B (five trials with the horizontal matrix and five trials with the vertical) and ten trials of Condition C (with '5 and 5', as above). The only difference between the stages was the difference in their centre-to-centre ratios. In all trials in every condition, the responses of the subjects were differentially rewarded - the reward contingencies reflecting those of the training phase of the original discrimination.

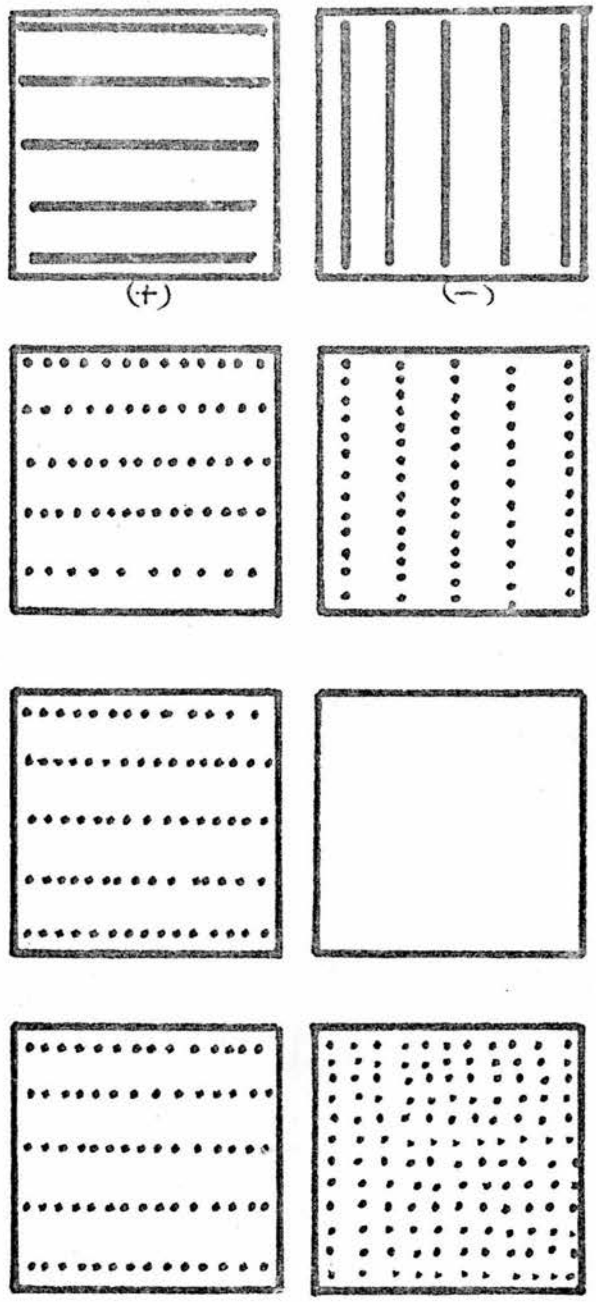
Following acquisition of the original discrimination, all subjects proceeded to Stage one (ration of 3 : 1), and worked progressively through to Stage eight (ratio of 1· 3 : 1), each subject being treated identically with the exception of the reward contingencies defining the two groups. This sequence of events was called Run one. The run was repeated (see Results and Discussion sections for reasons) with the/

Condition T.

Condition A.

Condition B.

Condition C.



<u>Figure 13 (4)</u>. <u>Representative stimulus pairs from the transfer testing phase of Experiment 3 (4)</u>.

Notes: The 'positive' exemplars of Conditions B & C are shown, for the corresponding reward contingencies of Conditions A & B.

the addition of an extra stage (Stage nine, centre-to-centre ratio of 1· 2 : 1). Further, in between the two runs, a series of ten trials were interposed, in which Condition B was run but with the corresponding continuous stimulus replacing the matrix.

RESULTS

Acquisition Performance

Table 5 (4) shows the symmetry of performance for Group H and V, on learning the original discrimination. The difference in the number of errors to criterion between the two groups was not significant, (t-test for independent measures - $t = 0.63$; $df = 6$; $p > 0.25$ for a two-tail test).

Transfer Testing Performance

The data was tabulated, then graphed and then analysed statistically.

Figure 14 (4) displays the combined performance of the two groups on each stage for each of the four conditions, in terms of percentage number of trials correct, for Run one. The corresponding information for Run two, is displayed in Figure 15 (4). Table 6 (4) and Table 7 (4) contain the respective table of values from which the two graphs of the figures mentioned above were drawn. Visual inspection of the graphs indicate that there is a considerable degree of positive transfer from the original discrimination (i.e. Condition T), during Run one, to the discontinuous version (i.e. Condition A) at Stage one. However, the transfer to Conditions B and C, whilst positive, is slight. In Run two, however, the corresponding transfer to Conditions

B/

Group	Subject	Errors to criterion
V	1	16
	2	15
	3	40
	4	20
	Mean	23
H	5	22
	6	20
	7	17
	8	63
	Mean	30

Table 5 (4). The acquisition performance of Group V and Group H for the discrimination training of Experiment 3 (4).

Note: The scores do not include the criterion run.

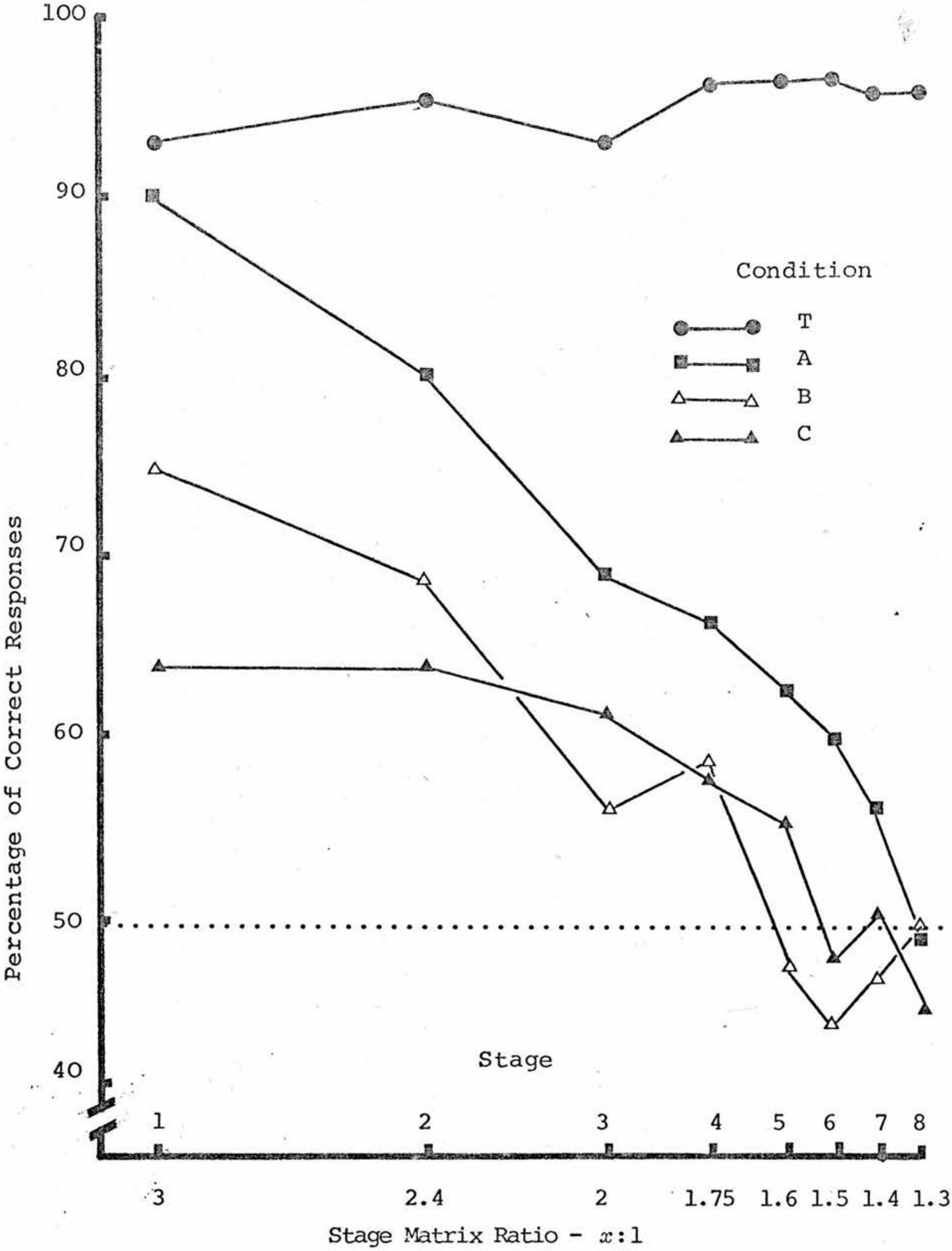


Figure 14 (4). Performance of the 2 groups combined on each of the 4 transfer Conditions for each Stage, during Run 1 of Experiment 3 (4).

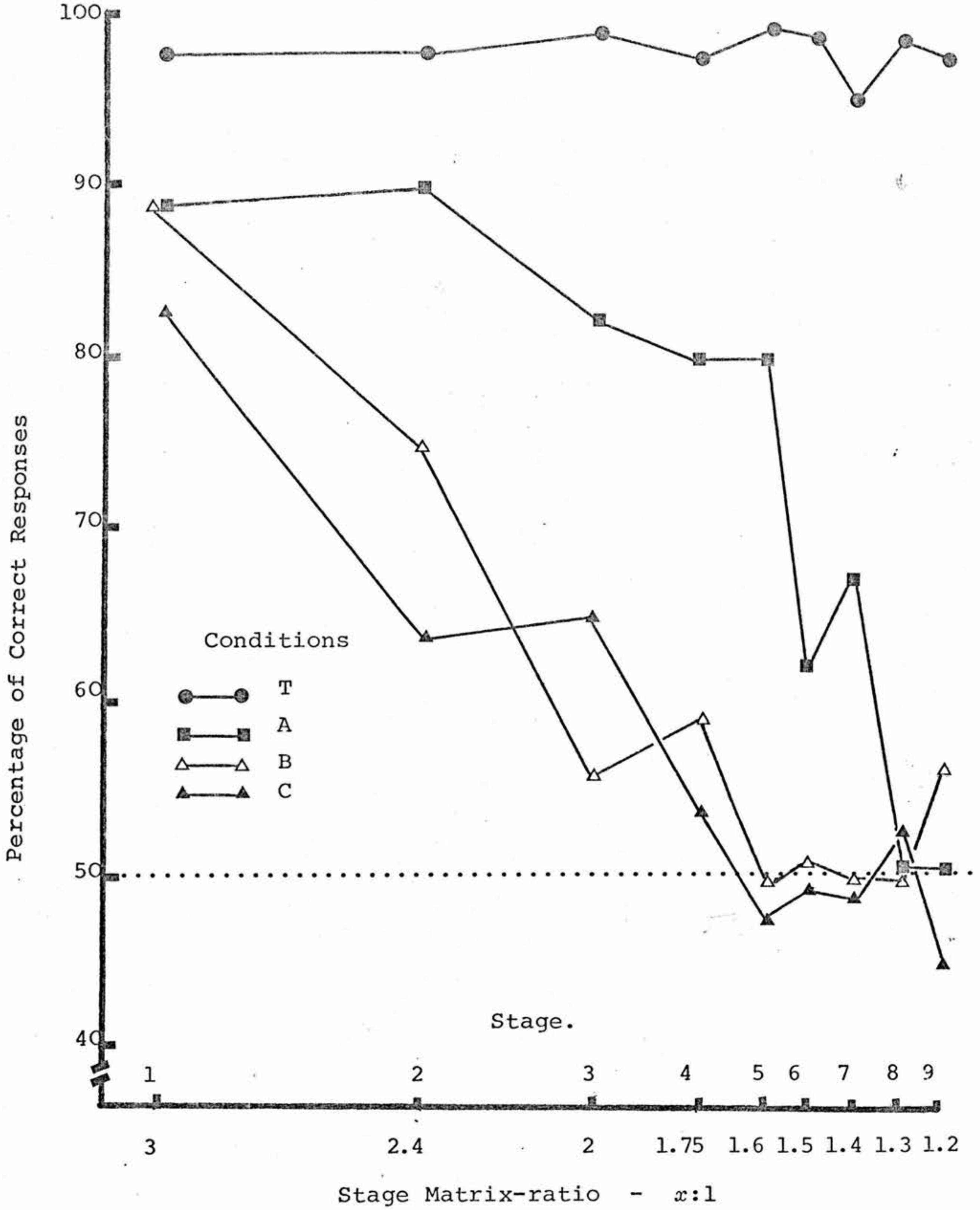


Figure 15 (4). Performance of the 2 groups combined on each of the 4 transfer Conditions for each Stage, during Run 2 of Experiment 3 (4).

Stage	Conditions			
	T	A	B	C
1	94.5	90	75	63.8
2	95.8	80	68.8	63.8
3	94.5	67.5	56.3	61.3
4	96.3	66.3	58.8	57.3
5	96.3	62.5	47.5	55
6	96.7	60	43.8	47.5
7	95.8	56.3	46.3	50
8	95.8	48.8	50	45

Table 6 (4). A table of the percentage positive transfer to the transfer Conditions for each Stage during Run 1 of Experiment 3 (4).

Stage	T	A	B	C
1	97.5	88.8	88.8	82.5
2	97.5	90	75	63.8
3	98.3	82.5	56.3	65
4	97.5	80	58.8	53.8
5	99.6	80	50	47.5
6	98.3	62.5	51.3	48.8
7	95.8	67.5	50	48.8
8	98.3	51.3	50	53.8
9	97.5	51.3	57.5	45

Table 7(4). A table of the percentage positive transfer to the transfer Conditions for each Stage during Run 2 of Experiment 3 (4).

B and C is positive and strong. Further, during Run two, the choice behaviour of the subjects in Condition A is maintained for more stages than in Run one. Otherwise, the performance of the subjects in both of the runs was similar, in that the discrimination was maintained longer in Condition A, than in Conditions B and C.

A Treatments-by-Treatments-by-Subjects Design analysis of variance (Winer, 1962, page 289) was performed on the data for the two runs. Analysis of the data for Run one showed a significant difference between stages ($F = 9.74$; $df = 7,49$; $p < 0.01$ - See Table 8 (4) for Source Table), and between the Condition A, B and C ($F = 9.79$; $df = 2,14$; $p < 0.01$ - See Table 8 (4) for Source Table), but the stage-condition interaction did not reach significance ($F = 0.66$; $df = 14,98$; $p > 0.3$ - See Table 8 (4) for Source Table). For Run two, however, as well as there being a significant difference between the stages ($F = 15.95$; $df = 8,57$ $p < 0.01$ - See Table 9 (4) for Source Table), and conditions ($F = 43.79$; $df = 2,14$; $p < 0.01$ - See Table 9 (4) for Source Table), there was a significant stage-condition interaction ($F = 5.37$; $df = 16,112$; $p < 0.01$ - See Table 9 (4) for Source Table). The analysis of variance goes towards confirming what the graphs have suggested. The interpretation of the significant F-values thus derived is as follows:

A t-test for Individual Comparisons Following a Significant F (Winer, 1962), using the error term obtained from the previous analysis of variance, was applied to each stage for comparison between Condition A and B, Condition B and C, and Condition A and C. The results of the comparisons for Run one and Run two are shown in Table 10 (4) and Table/

Source	SS	DF	MS	F
Total	693.98	191	-	-
Subjects	44.39	7	-	-
Stages	176.82	7	25.26	9.74 *
Conditions	48.87	2	24.44	9.79 *
Stage x Cond.	23.03	14	1.65	0.66
Error (Sta)	127.09	49	2.59	-
Error (Cond)	34.95	14	2.50	-
Error (St x C)	243.80	98	2.49	-

Table 8 (4). Source Table of the variance contributed by the Subjects, Stages and Conditions of Experiment 3(4) during Run 1.

Note: * signifies an *F* significant below the 0.01 level.

Source	SS	DF	MS	F
Total	714.59	215	-	-
Subjects	2.00	7	-	-
Stages	252.93	8	31.62	15.95 *
Conditions	123.90	2	61.95	43.79 *
Stage x Cond.	69.26	16	4.33	3.57 *
Error (Sta)	110.99	56	1.98	-
Error (Cond)	19.81	14	1.42	-
Error (St x C)	135.70	112	1.21	-

Table 9 (4). Source Table of the variance contributed by the Subjects, Stages and Conditions of Experiment 3(4) during Run 2.

Note: * denotes an *F* significant below the 0.01 level.

Stage	Comparison							
	Between A-B			Between A-C			Between B-C	
	t	*p*		*t*	*p*		*t*	*p*
1	1.90	0.05	*	3.32	0.005	***	1.42	0.20
2	1.42	0.10		1.90	0.05	*	0.47	0.80
3	1.42	0.10		-0.32	0.40		-1.74	0.20
4	0.95	0.25		1.11	0.25		0.16	0.80
5	1.90	0.05	*	0.95	0.25		-0.95	0.50
6	2.06	0.05	*	1.58	0.10		-0.47	0.80
7	1.27	0.25		0.79	0.25		-0.47	0.80
8	-0.16	0.40		0.47	0.40		0.63	0.80

Table 10 (4). Comparisons between the 3 Conditions of transfer testing for each Stage of Experiment 3 (4), during Run 1.

Note: The *p*-values displayed are 1-tailed.

The significant *p*-values are highlighted with asterisks, 0.05 = *, 0.01 = **, 0.005 = ***, 0.001 = ****.

The differences in the least frequent direction are indicated with a minus sign (including the *t*-value).

Table 11 (4), respectively. As can be seen from inspection of the tables, a clear pattern of difference does not emerge from Run one. For Run two, however, a pattern of differences reaching significance does emerge, in that differences between Conditions A and B, and between A and C reached significance in Stages two to seven, inclusive.

In order to make individual comparisons between the stages for the performance in each of the conditions, seperately, a Newman-Keuls Range Test (Winer, 1962) was used. Since the performance of subjects on Condition B and C was very similar throughout the experiment (the previous analysis has shown this), these conditions were combined for this analysis. The results of the comparisons are recorded in Table 12 (4) for Run one, and Table 13 (4) for Run two. During Run one, and for Condition A, significant differences in scores were only present between Stage one and Stage two, and the other stages - indicating a sharp fall-off in performance from Stage one to Stage three. For Condition 'BC' (i.e. B and C, combined), the picture was somewhat similar - however, the comparisons had to be at least four stages apart to be significant, in contrast to the two stages apart of Condition A. On Run two, and for Condition A, however, the pattern of the comparison-matrix shows a considerable shift of the rapid fall-off region towards the later stages, whilst Condition 'BC' shows a similar pattern to that of Run one.

In order to establish at what stages and in which conditions the subjects' performance departed from chance choice behaviour, binomial tests ($p = q = \frac{1}{2}$) were performed on all of the stages for each condition. Table 14 (4) records the p-values associated with the number/

Stage	Comparison							
	Between A-B			Between A-C			Between B-C	
	t	p		t	p		t	p
1	0.85	0.25		1.05	0.25		0.21	0.80
2	2.52	0.025	x	4.41	0.001	****	1.89	0.10
3	4.41	0.001	****	2.94	0.01	**	-1.47	0.20
4	3.57	0.005	***	4.41	0.001	****	0.84	0.50
5	5.04	0.001	****	5.46	0.001	****	0.42	0.80
6	3.57	0.005	***	3.99	0.001	****	0.42	0.80
7	2.94	0.01	**	3.15	0.005	***	0.21	0.80
8	0.21	0.40		-0.42	0.4		-0.63	0.80
9	1.05	0.25		1.63	0.25		2.10	0.10

<u>Table 11 (4)</u>. <u>Comparisons between the s Conditions of transfer testing for each Stage of Experiment 3 (4) during Run 2</u>.

Note: The p-values displayed are 1-tailed.

The significant p-values are highlighted with asterisks, 0.05 = *, 0.025 = x, 0.01 = **, 0.005 = ***, 0.001 = ****.

The differences in the least frequent direction are indicated with a minus sign (including the t-value).

Condition A.

	8	7	6	5	4	3	2	1
8							**	**
7							*	**
6								**
5								**
4								**
3								**
2								
1								

Condition 'BC'.

	8	7	6	5	4	3	2	1
8							**	**
7							**	**
6							**	**
5							*	**
4								
3								
2								
1								

Table 12 (4). The location of significant differences between the different Stages for Condition A, and 'BC', during Run 1 of Experiment 3 (4).

Note: Newman-Keuls Range Tests were used for the comparisons.
* = 0.05 level of significance, ** = 0.01 level.

Condition A.

	9	8	7	6	5	4	3	2	1
9				**	**	**	**	**	**
8				**	**	**	**	**	**
7							*	**	**
6								*	*
5									
4									
3									
2									
1									

Condition 'BC'.

	9	8	7	6	5	4	3	2	1
9								**	**
8								**	**
7								**	**
6								**	**
5								**	**
4								*	**
3									**
2									**
1									

Table 13 (4). The location of significant differences between the different Stages for Condition A, and 'BC', during Run 2 of Experiment 3 (4).

Note: Newman-Keuls Range Tests were used for the comparisons.

* = 0.05 level of significance, ** = 0.01 level.

Stage	Condition of Run 1			Condition of Run 2		
	A	B	C	A	B	C
1	0.004 **	0.004 **	0.365	0.004 **	0.004 **	0.004 **
2	0.004 **	0.145	0.145	0.004 **	0.004 **	0.145
3	0.145	0.637	0.363	0.004 **	0.855	0.145
4	0.145	0.363	0.855	0.004 **	0.145	0.363
5	0.145	0.637	0.637	0.004 **	0.855	0.855
6	0.145	0.855	0.855	0.004 **	0.637	0.965
7	0.363	0.965	0.637	0.035 *	0.965	0.637
8	0.855	0.855	0.965	0.637	0.637	0.855
9	-	-	-	0.855	0.637	0.996

Table 14 (4). A table of the probabilities associated with the number of subjects exhibiting a choice bias in favour of the original discrimination, for each condition of transfer on each stage.

Note: * = 0.035 and ** = 0.004.

number of subjects showing a choice bias (reflecting Condition T performance) for each condition on each stage. The superiority of Condition A over B and C is clearly seen for Run two, <u>even though the three conditions have a similar level of performance in the first stage</u>. No such contrast is seen for the data of the first run.

Figures 16 (4) and 17 (4) display the performance for Conditions B and C combined, distinguishing between trials where the vertical stimulus was present (paired with either the 'blank' or the regular matrix) and trials where the horizontal stimulus was present. Visual inspection of these two figures indicate that the vertical discontinuous stimulus controls choice behaviour, in these conditions of test, far more than the corresponding horizontal stimulus - a result which is quite clear in both runs and in virtually all stages. A further analysis of this behaviour was carried out using a three-Factor Mixed Design, With Repeated Measures on two Factors analysis of variance (Winer, 1962), page 319). The analysis indicated significant differences exist between the stages (Run one - $F = 5.87$; $df = 7,42$; $p < 0.01$. Run two - $F = 11.9$; $df = 8,48$; $p < 0.01$ - See Table 15, Table 16 (4) for Source Table), and between the conditions 'vertical present' and 'horizontal present' (Run one - $F = 18.56$; $df = 1,6$; $p < 0.01$. Run two - $F = 20.52$; $df = 1,6$; $p < 0.01$ - See Table 15 (4) for Source Table). Neither the difference between the performance of the groups, nor the possible interactions between groups, stages and 'vertical present' or 'horizontal present' reached significance.

DISCUSSION

When/

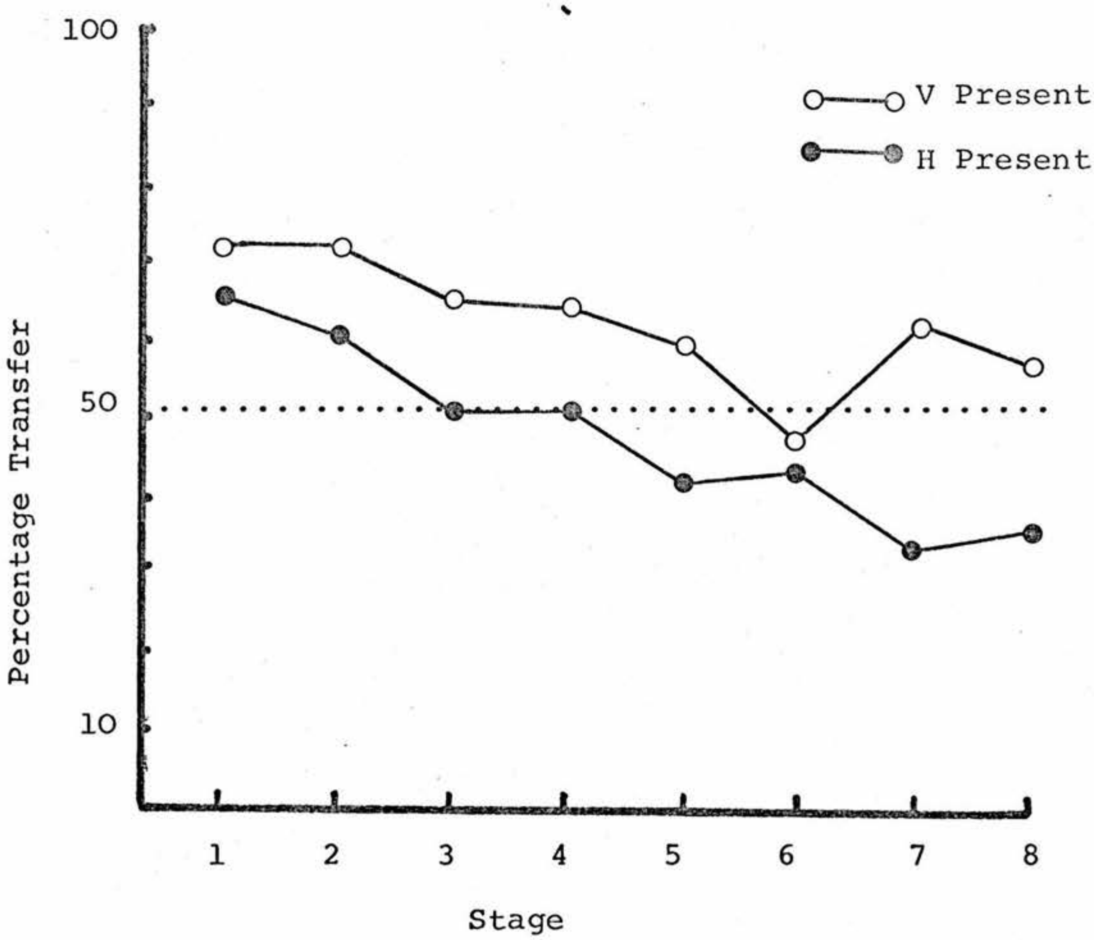


Figure 16 (4). Performance for Condition B and C combined, distinguishing between those trials where the 'vertical'was present and those where the 'horizontal' was present, in Experiment 3 (4). during Run 1.

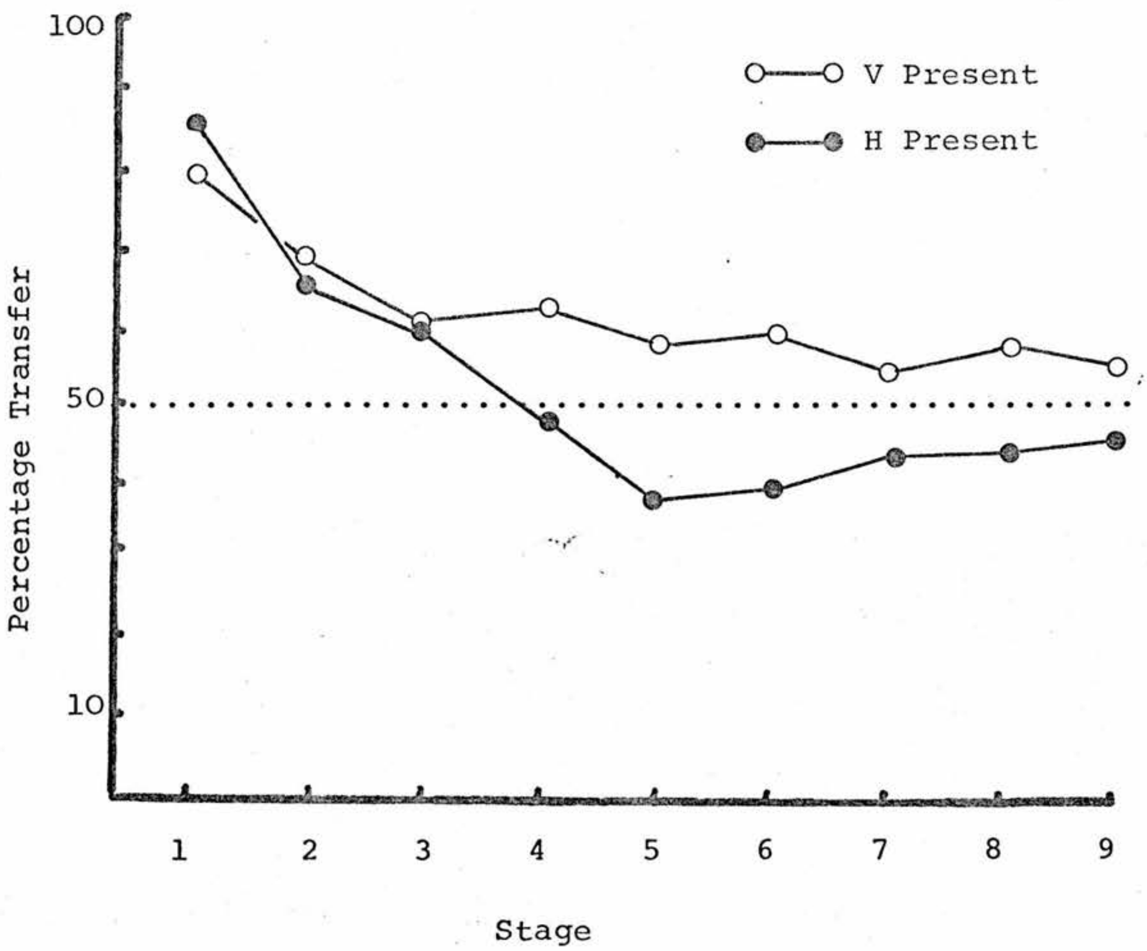


Figure 17 (4). Performance for Condition B and C combined distinguishing between those trials where the 'vertical' was present and those where the 'horizontal' was present in Experiment 3 (4) during Run 2.

Source	SS	DF	MS	F
Total	483.37	127	-	-
Bet. Subs	31.81	7	-	-
Groups	6.57	1	6.57	1.56
Error	25.23	6	4.21	-
With. Subs	451.55	120	-	-
Stages	91.68	7	13.10	5.87 *
V-H	70.51	1	70.51	18.56 *
Gps x Stg	27.74	7	3.96	1.78
Gps x V-H	11.88	1	11.88	3.13
Stg x V-H	18.81	7	2.69	1.32
Gps x VH x Stg	28.93	7	4.13	2.09
Error-1	93.64	42	2.23	-
Error-2	22.80	6	3.80	-
Error-3	35.57	42	2.04	-

Table 15 (4). Source Table of the variance contributed by the Subjects, Groups, Stages, and 'Vertical present/Horizontal present' condition of Experiment 3 (4), during Run 1.

Note: Error-1 was used for Stages and Stg x Gps.

Error 2 was used for V-H and V-H x Gps.

Error-3 was used for Stg x V-H and Gps x VH x Stg.

* denotes an *F*-value significant below the 0.01 level.

Source	SS	DF	MS	F
Total	447.47	143	-	-
Bet. Subs	3.53	7	-	-
Groups	0.70	1	0.70	1.47
Error	2.83	6	0.47	-
With. Subs	444.44	136	-	-
Stages	165.57	8	20.75	11.90 *
V-H	34.03	1	34.03	20.52 *
Gps x Stg	19.81	8	2.46	1.42
Gps x V-H	1.36	1	1.36	0.81
Stg x V-H	25.47	8	3.18	1.61
Gps x VH x Stg	9.14	8	1.14	0.58
Error-1	83.67	48	1.74	-
Error-2	9.95	6	1.65	-
Error-3	95.05	48	1.98	-

Table 16 (4). Source Table of the variance contributed by the Subjects, Groups, Stages, and 'Vertical present/Horizontal present' condition of Experiment 3 (4), during Run 2.

Note: The error terms are explained in the notes of Table 15(4).

* denotes an *F*-value significant below the 0.01 level.

When comparisons between the stages of the current experiment and those of the previous two experiments are appropriate (i.e. equivalent stage-matrix ratios), the results of the current experiment are in detailed agreement with the results reported, thus far.

It was predicted that during Experiment 3 (4) the difference between Condition T and Conditions B and C would be very much reduced (unlike in the previous two experiments), if not disappear altogether, during Stage one, since the centre-to-centre ratios of this stage (i.e. 3 : 1) was such as to approximate the individual stimuli of Condition T (i.e. the continuous striations), and Experiment 1 (4) and 2 (4) had, already, demonstrated that such stimuli when paired with 'blanks' still retain their capability to control choice behaviour. It was, further, predicted that as the centre-to-centre ratio of the matrices was reduced from Stage one to eight, the differences between Condition A and the critical conditions (B and C) would be, initially, small or non-existent (from the rationale above) would develop and be of the order of the previous two experiments as the stages were reached which had ratios similar to those of the previous two experiments, and then disappear again as the final stages were reached - when the matrix ratios would be such that organization under <u>any</u> circumstances of test would become impossible as the physical organization, itself, would disappear. Both visual inspection of Figure 14 (4) and 15 (4) and the corresponding analysis of variance indicates this to be the case for Run two but not for Run one, where even on Stage one, differences between Condition A and B and C exist. A possible explanation might lie in the fact that the average performance of the subjects can be seen/

seen to improve slightly over the stages of Run one as measured by Condition T. Although good at Stage one, a perceptible trend to improve can be seen in Figure 14 (4) and 15 (4) the average performance of subjects during Run two for Condition T is never at any stage below that of the corresponding stage of Run 1. Since the Stage 1 performance of Run one was not as predicted, and in light of the trend to improve (albeit quite small) during Run one for Condition T, the decision was taken to rerun Stage one following the last stage of Run one - the rationale being that if the relatively low performance on the two critical conditions was a result of lack of stability in responding, this should no longer be the case by the time Run one had been completed. The results of the rerun of Stage one support this explanation in that no difference between Conditions A, B and C was detected. The, further, decision was taken to complete Run two since the performance during this second run would be of extensively trained (and stable) subjects, and therefore more reliable. The results of Run two were as predicted, above, and further confirm the findings of Experiment one (4) and 2 (4), but using a vastly more extensive and exacting procedure.

The fact that during Experiment 3 (4) subjects treated Condition B and C as equivalent, lends support to what has been suggested on the basis of the results of Experiment 1 (4) and 2 (4), that it is not the mere presence of the novel 'blank' stimulus that is disruptive of the choice behaviour - since the stimulus pair of Condition C closely resembles that of the highly successful transfer condition - Condition A.

A/

A further interesting outcome of the current experiment was that the suggestion from Experiment 1 (4) that rats on a Jumping Stand can organize 'vertical' matrices much more reliably than 'horizontal' ones was convincingly confirmed.

D I S C U S S I O N   O F   C H A P T E R   F O U R

The experiments reported in this chapter, taken as a package, indicate that in the rat and the squirrel monkey, organization of matrices, as indicated by choice behaviour, only occurred under special conditions of stimulus presentation - i.e. a matrix was only organized when it was paired with, or related to, an 'appropriate' comparison stimulus. The 'appropriateness' of any stimulus has, thus far, been nothing more than operationally defined - i.e. if the testing procedures indicated that a matrix of a test pair was readily organized by a subject, then the other stimulus was (by definition) an 'appropriate' comparison stimulus. And, similarly, if no such organization was evident from the behaviour, the other stimulus was an 'inappropriate' comparison stimulus. The interesting question arises as to what it is about some stimuli that makes them 'appropriate' and about others that makes them 'inappropriate', in the discriminations in question.

Comparison stimuli which have been categorized as 'appropriate' have been matrices, themselves, but physically organized in a direction at right angles to the target matrix. There have been four types of 'inappropriate' comparison stimulus: a discontinuous 'X' (Krechevsky 1938b, the 'easy' condition, Figure 2b-4); a 'blank' stimulus (the current series of experiments); a 'regular' matrix (Experiment 3-4); and a stimulus of continuous striations in the same direction of orientations as the physical organization of the matrix with which it is simultaneously presented (all the experiments in which A.T.E. has been tested for). The first three categories are defined by not having a/

a specific single direction of orientation - the continuous stimulus <u>does</u> have an unambiguous direction or orientation, but in the <u>same</u> direction as the physical organization of the matrix with which it is compared. The significance of this is as follows:

It is argued that in Experiment 1 (4), the rats learn the discrimination on the basis of the orientation that is perceived in the two matrices, and that in both Experiment 2 (4) and Experiment 3 (4) the same directionality is the basis for the discrimination learning. However, in Experiments 2 (4) and 3 (4), the index of direction is strong and unambiguous (it is difficult to imagine what could be a more stronger index of direction than the continuous stripes), whereas in the matrices of Experiment 1 (4) the index is much weaker and more ambiguous, since the number of possible organizations that can be imposed upon such matrices must be, theoretically, large. What is it, then, that causes the matrices to be organized in such a way as to produce unambiguous orientation cues in some cases, but not in others?

In formulating an answer to this question, the lead of Garner (1962, 1966) has been followed. Garner writes of the problems involved in defining as single stimulus (Garner 1966, page 11):

"Yet a single stimulus can have no real meaning without reference to a set of stimuli because the attributes which define it cannot be specified without knowing what the alternatives are . . . . How the single stimulus is perceived is a function not so much of what it is, but rather is a function of what the total set and the particular subset are."

It/

It is well-known that the vertical and horizontal orientations are more easily identified (but not necessarily discriminated) than opposing oblique orientations (e.g. Kinsbourne, 1966), and Levere (1966) has shown that chimps have greater difficulty in completing linear dot pattern in oblique rather than horizontal and vertical orientations. With these points in mind, the current author argues that the simultaneous presence of matrices physically organized in the two orientations that are most easily identified (i.e. vertical and horizontal) and appear on the basis of behavioural evidence to form a class of their own (i.e. exclusive of obliques), is sufficient to greatly constrain the organization which the active perceptual system can thereon impose. In Garner's terms, the total set of organizations (i.e. the total set of stimuli) is greatly reduced by the apparent special nature of the vertical and horizontal orientations, and when the two stimuli of this particular subset are simultaneously present, the natural constraint on the number of organizations then possible is further increased. When only one of this subset is present (i.e. when an 'appropriate' comparison stimulus is absent), the constraint is not sufficient for the vertical or horizontal organization to be inevitably imposed. 'Appropriateness', then, becomes not a property of the single (comparison) stimulus, but is a property, in the current cases, of the pair. Indeed, Bower (1969) has been unable to demonstrate proximity effects in infants using a successive rather than a simultaneous discrimination task - a method that would make stimulus comparison much more difficult by imposing a longer time interval between successive scans of the discriminanda. And Bryant (1970) reports that a delay of only five seconds completely disrupts discrimination behaviour in subnormal adults when based on cues/

cues involving the relative position of a dot (not unlike the experiments reported in the current chapter).

The relational character of the discriminations in the current chapter (made by rats and squirrel monkeys) is in close agreement with expectations based on the results of a developmental study by Gibson, Pick and Osser (1962) on the discrimination of letter-like forms. These investigators found (and their results have been replicated with squirrel monkeys by McGonigle, Osborne and Jones - paper in preparation) that the identification of a given (standard) stimulus was markedly affected by the character of the alternate stimulus from which it was chosen. Gibson _et al_ interpret their results as forming support for a 'distinctive feature' hypothesis (Gibson, 1968), there are important reasons, however, which refrain the current author from doing likewise.

Gibson appears to have ignored the importance of context in the advocacy of her theory. Yet it would appear to be a logical point that just as the stimuli _qua discriminanda_ have to be discriminated from one another, they must also be differentiated _as a set_ from other stimuli which form the ground on which they appear. Thus, the criteria defining the stimuli _qua set_ need to be established independently of the criteria which must be used to discriminate and identify the differences _within_ it. For example, a Ford car is not defined perceptually such that its differentiation from a pedestrian, a block of apartments, a cloud or other makes of car will invariably exploit the same features (which is a common assumption in pattern recognition). On the contrary, the defining attributes of a particular model or make of car must be related to the set or population within which it is

(perhaps/

(perhaps only temporarily) embedded. Without knowledge of the group to which the descriptor of a car may refer (or at least the provision of a basis for speculation as to what it might be), the choice of 'distinctive criteria' in very much unconstrained, and the process of indentification rendered impotent as a consequence.

Such results and interpretations have particular relevance to feature-detection theories of pattern recognition (and, indeed, those employing holistic template-matching, too). It is clear that it may not be sufficient to develop a theory of pattern recognition merely involving the collection of features from the environmental patterns and their (successful or otherwise) matching against some stored specific feature bank, or bank containing collections of features. It is, perhaps, undeniable that features are encoded at the retinal level and, indeed, more centrally, in a manner similar to that which, for example, Hebb (1949) and Dodwell (1971) propose - the single-cell recording experiments of the type performed by Hubel and Wiesel, for example, produce results which support this view. However, it is a great act of faith to expect (as does, for example, Dodwell) that the answers to the questions raised about perception of patterns can be gained from this level of investigation - and the results of the experiments reported in the current chapter raise just some of the problems which such approaches would need to overcome. Thus, the current author must take issue with part of the concluding statement made by Dodwell in a recent book <u>Perceptual Processing: Stimulus Equivalence and Pattern Recognition</u> (Dodwell 1971, page 519):

"I/

"I believe that the most fruitful line of inquiry and development in this field, <u>for psychologists</u> (the present author's italics), is to continue to look for pattern recognition behaviour which supports the receptive-field principle, and also to find ways of investigating, and modelling, the integration of such coding with more general aspects of pattern recognition."

For, whilst Dodwell's ultimate goal of integrating the various areas of investigation is most worthwhile, the results of the experiments reported, herein, strongly indicate that what he suggests as the 'most fruitful line of inquiry' is not.

C O N C L U S I O N S

What, then, are the main conclusions that can be drawn from the studies reported in the previous three chapters?

Firstly, the current author believes that the experimental evidence that has been presented is overwhelmingly in favour of a 'relational' position. Over a wide range of 'dimensions', animals have been found to form discriminations on the basis of perceived relationships between the discriminanda which are not endemic to the (individual) stimuli, themselves, but are constructions of the perceiver. There is no such thing in the environment as a 'largest' stimulus, a 'middle' stick, a 'brightest' target; these tags refer not to stimuli, themselves, but to the relationships between and amongst stimuli in what are specifiable sets. Thus, a priori, the use of stimulus relations demands a frame of reference (i.e. a context, a category, a class, a well-defined set or population of stimuli) otherwise, 'middle' or 'larger' or 'brightest' would be totally meaningless tags.

Here, too, the monkey data show clear evidence of such referencing systems which the use of relational terms would (logically) require. For example, the results produced from experiments of Chapter 2 and 3 in which the context was manipulated.

The second main conclusion is that 'absolute' stimulus learning/ encoding is, in practice, a relational response, but of much greater complexity than a response to 'brighter' or 'largest', for example. The evidence for this is as follows:

(a)/

(a) When forced to recognize a specific stimulus, it was found that monkeys experience much more difficulty in accommodating such task requirements than is the case when other discriminations of a 'relational' nature are involved. This conflicts with the Spencian notion.

(b) Success in identifying specific stimuli is highly set or context dependent. The results of the final experiment of the 'size' series is but one case to point. If it were the case that the ability to conserve a specific stimulus value was evidence for 'absolute' learning, then it should not be expected that that response be so dependent upon the system of reference described.

This conception of an 'absolute' stimulus stands in marked contrast to one involving a predetermined, inevitable representation which is produced irrespective of (in total disregard of) any other stimuli of the same or other class. It is interesting to note the concordance of these views (resulting from the monkey investigations) with those reported by Vernon (1962 - to which reference has already been made) in the area of human psychophysics.

THE FUTURE

The conception of relational perception which has been developed in the foregoing chapters, stands in marked contrast to that conventionally held in the domain of comparative psychology. Although the Spence/Hull system has long been overthrown in human psychology, it is, nevertheless, the case that its heritage is still pronounced in animal research/

research (Hodos and Cambell 1969, demonstrate this). Indeed, even in the extensive treatise of Skinner (1961), his theory of behaviour makes no reference to relationships - which the current studies have shown to be of fundamental importance.

If (as these studies show) the perception of stimulus relations is basic/*a priori*, there is encouragement, thus, for further search for other constructions which animals may be capable of generating, for example, seriation and order relations, conservation of weight and size, and the co-ordination of the different relations. This latter quest is seen as being particularly pertinent as a new basis for the development of the comparative psychology of learning and perception.

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THESIS DECLARATION.

I declare that the work reported in the current thesis is my own, having been completed within the normal terms of reference of supervision (by Dr. B.O. McGonigle) in the Faculty of Science in the University of Edinburgh Scotland.

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