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THE DEVELOPMENT OF GENERALIZED IMITATION WITHIN TOPOGRAPHICALLY DETERMINED BOUNDARIES[1]

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A multiple baseline technique was employed to examine the experimental development of an imitative repertoire within preselected topographical boundaries. Four severely retarded children, initially nonimitative, were individually trained to imitate a number of motor and vocal responses by shaping and fading procedures. Other untrained responses (probes) were demonstrated to the subjects systematically throughout the ongoing training. Training responses were divided into three topographical types: small motor, large motor, and short vocal responses. Probe responses were divided into four topographical types: small motor, large motor, short vocal, and long vocal responses. Following a multiple baseline format, sequential training of the first three types was begun at different temporal periods of the study; unreinforced imitative generalization was continually measured by the probes. Generalized imitation was observed in each subject (untrained responses were imitated even though unreinforced); but this generalization was restricted to the topographical type of imitation currently receiving training or having previously received training.

Imitation, in behavioral terms, identifies a class of behaviors similar to those behaviors of another organism which precede them. Any individual's behavior can be identified as imitative if it temporally follows the behavior of another individual and if its topography is controlled by the demonstrated behavior (Baer, Peterson, and Sherman, 1967). It is important to emphasize the controlling role of topographical similarity of the two behaviors in order to distinguish imitative behavior from other types of matched responding, such as Miller and Dollard's (1941) "matched-dependent" behavior.

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Exemplifying the recent experimental analysis of imitation, Baer and Sherman (1964) found with preschool children that repeated social reinforcement of three imitative responses led to imitation of a fourth response, which was never reinforced. Experimental manipulation indicated that it was the reinforcement of the first three imitations that maintained the non-reinforced fourth imitation. Similar results were obtained in other experiments with developmentally retarded subjects, in whom an imitative repertoire was initially absent. Metz (1965), Lovaas, Berberich, Perloff, and Schaeffer (1966), and Baer, *et al.* (1967) trained motor imitations in imitation-deficient subjects; concurrently while reinforcing imitation of some responses, other responses were demonstrated but imitations of them were never reinforced. Two consistent behavioral results were seen: (1) Successive responses receiving training were learned faster (in fewer demonstrations); (2) Imitations that were never reinforced increased when other imitations were reinforced but decreased when other imitations were not reinforced.

Thus, a group of behaviors was concurrently modified by operations applied to only a subset of the group. This interaction within a group of behaviors defines the group as a *functional response class* (Baer *et al.*, 1967; Peterson, 1968; Risley, 1966; Skinner, 1938). This concept is descriptive; it merely identifies a set of topographically different responses whose probabilities of occurrence vary together, even though only some of the responses are directly controlled by an effective stimulus. (Risley and Baer, 1971). In the case of imitation, the evidence indicates that a response class can be established by reinforcement of enough different imitations; the result is a general tendency to imitate new responses on their first demonstration.

Although the development and existence of imitative response classes (the generalization of imitation) has been demonstrated, their dimensions of variability have not received detailed experimental attention. In one study (Baer *et al.*, 1967), first motor and then verbal imitations were trained. Two subjects initially failed to imitate a simple verbal response demonstration even after new motor response demonstrations were being imitated with near-perfect reliability. Further training of some vocal imitations was then instituted to produce general vocal imitation in these subjects. Risley (1968) reported training topographically different (gross motor, fine motor, facial and verbal) imitation in disadvantaged preschool children. During training, one or another component of a topographically complex response was singled out for intensive training. During test trials, a model demonstrated the entire complex response; the children imitated the complex response in some detail but were most accurate with the component being trained at that time. These few studies suggest that imitation need not be one large response class, but instead can be made up of different, topographically distinguishable subclasses, which thus define—*i.e.*, restrict—its overall generalization. As with other response classes, the limits of generalized imitation may possibly be determined by reinforcing only a selected range of imitative response topographies. It is to this point that the present research was addressed. At issue was the control of the limits of generalization of imitation, as effected by training different topographical types, or groups, of imitations. These different types or groups were chosen to maximize topographical similarity of responses within each type and topographical dissimilarity of responses between types. Topographic similarity was chosen as one possible (and easily observable) way of organizing imitative subclasses; there may well be other dimensions for organizing such subclasses.

METHOD

Subjects and Setting

Two female (S1 and S3) and two male (S2 and S4) residents of the Kansas Neurological Institute, an institution for the mentally retarded, were selected. Their ages ranged from eight to 14 yr; all had been institutionalized for at least 4 yr. They had no physical impairments, were able to respond correctly to simple verbal commands (come here, sit down, *etc.*), and made some vocal sounds (but nothing judged as words). Criterion for their selection was the apparent absence of spontaneous imitative and verbal (as distinct from vocal) repertories. Previous records, discussions with ward personnel, and ward observations by the experimenter were used to evaluate this criterion. In addition, each subject was seen in a pretraining session in which certain responses used later in the study (as probes) were demonstrated to the subject twice each. During this session, sweets were provided noncontingently on a variable-interval schedule; the subjects imitated few or none of these demonstrations.

Subjects were seen individually in 15- to 30-min sessions, once or twice daily, two or four days weekly over an 11-month period. Sessions were conducted in a small experimental room connected by a one-way mirror to an adjoining observation room. Each trial began with the subject and experimenter seated opposite each other at the side of a table. Reinforcement was accomplished by the experimenter's saying "good" and then placing a sweet (a spoonful of ice cream or a miniature marshmallow) in the mouth of the subject.

Procedure

General training. Subjects were successively trained to imitate a number of different responses demonstrated by the experimenter. For training purposes, these responses were divided into three types: (1) small motor: responses performed by simple hand movements while seated; (2) large motor: responses

Table I

Sequence of Response Training and Probes for Each Subject

Sequence of Trained Responses		
Subjects 1 and 2	*Subject 3*	*Subject 4*
Small Motor	*Large Motor*	*Small Motor*
touch knee	touch door	touch knee
move tray	move wastebasket	move tray
PROBE	PROBE	PROBE
clap hands	pat radiator	clap hands
ring bell	walk and clap thighs	ring bell
PROBE	PROBE	PROBE
touch shoulder	twirl around	touch shoulder
throw paper wad	mark blackboard	throw paper wad
PROBE	PROBE	PROBE
touch head	touch distant chair	touch head
nest boxes	put object on radiator	nest boxes
PROBE	PROBE	PROBE
Large Motor	*Small Motor*	REPEAT TRAINING SEQUENCE FOR ABOVE
touch door	touch knee	touch foot
move wastebasket	move tray	touch table
PROBE	PROBE	PROBE
pat radiator	clap hands	touch jaw
walk and clap thighs	ring bell	flip magazine
PROBE	PROBE	PROBE
twirl around	touch shoulder	touch neck
mark blackboard	throw paper wad	touch hip
PROBE	PROBE	PROBE
touch distant chair	touch head	*Large Motor*
put object on radiator	nest boxes	touch door
PROBE	PROBE	move wastebasket
Short Vocal		PROBE
"aw" as in Paul		pat radiator
"a" as in Pat		walk and clap thighs
PROBE		PROBE
"oh" as in Joe		twirl around
"a" as in Kay		mark blackboard
PROBE		PROBE
"i" as in Ty		touch distant chair
"ee" as in Pete		put object on radiator
PROBE		PROBE
"u" as in Hugh		
"ah" as in Dot		
PROBE		

Probe Responses			
Small Motor	*Large Motor*	*Short Vocal*	*Long Vocal*
touch stomach	move chair	"i" as in Bill	"it"
empty box	open, close door	"uh" as in Bud	"but"
touch elbow	put object in wastebasket	"oo" as in Sue	"lewd"
wad paper	rustle window curtain	"eh" as in Ted	"pet"

performed by gross motor movements involving standing and walking; (3) short vocal: vowels.

Table I lists the responses taught to each subject, categorized according to type and listed in the order in which they were trained. Two imitations, always of the same type, were trained concurrently. That is, two responses were individually presented in alternation during a training session; imitation of each response was shaped on a continuous reinforcement schedule. No experimenter verbal response (*i.e.*, "Do this") accompanied a response demonstration.

Subject variations in general training. Subjects 1 and 2 were sequentially taught eight small motor, eight large motor, and eight short vocal responses (see Table I).

As a control for a training order effect, Subject 3 was first taught eight large motor, and then eight short motor responses (see Table I).

Subject 4 became a special case because of the little generalization observed after training in eight small motor responses (see Table I). He was retrained in these same eight small motor responses; then, when no increase in generalization was observed, he was trained in six new small motor responses. After receiving this extra training in small motor responses, he was trained in eight large motor responses. (Training of short vocal responses was attempted with Subjects 3 and 4, but was discontinued after two months because of the failure to produce useful progress in either subject.)

Specific training. The training of motor imitations involved shaping and fading procedures similar to those described by Risley and Wolf (1967) and Baer *et al.* (1967). Since each subject initially had little or no imitative skill, it was necessary for the experimenter to present a response model and physically guide the subject through the topography of the response. On successive presentations the experimenter faded out his assistance until the subject imitated the response independently.

Training of vocal imitations involved a lengthy shaping procedure of reinforcing successively approximations to the vocalized model. Each subject trained in this procedure did initially make sounds. In each case, the first step in training involved reinforcing the subject's response of attending to the experimenter's mouth and making any sound immediately after a vocal presentation. In order to train this eye contact, the reinforcer was placed in front of the experimenter's mouth before a vocal response was demonstrated. As can be seen in Table I, vocal responses accompanied by visual mouth cues ("o"—mouth is puckered; "ah"—tongue is out of mouth; "aw"—mouth is open wide) were trained first, to capitalize on these visual/cues. Visual mouth cues were first exaggerated, and then slowly faded to normal. Physical assistance in forming the subject's mouth was used for the vocal response "o"; otherwise, no manipulation of the subject's mouth was used.

Criterion and subsequent procedures. Training on each pair of responses was continued until one of two specified criteria was met: either (A) six successively correct imitations, three each of the pair being trained with each imitation occurring within 10 sec after its demonstration; or, (B) 15 complete sessions of training a pair of responses without reaching criterion A. However, training on the first pair of responses in each category continued until reaching criterion A (necessary to allow the scheduling of unreinforced probes, as will be explained later). After the first pair, training continued to criterion A or for 15 sessions (criterion B). During vocal training, another observer listened to the vocal tapes and scored the responses independently (audible consequences delivered by the experimenter were deleted); 100% agreement between observer and experimenter on criterion A for vocal responses meeting this criterion was required before thinning the schedule of reinforcement.

After criterion was reached, a maintenance procedure was applied. This procedure entailed modelling each previously trained response twice (omitting the pair just meeting criterion), and reinforcing each correct imitation. Immediately following, the pair just trained to criterion was gradually placed on a VR 3 schedule of reinforcement (proceeding stepwise from FR 2 to VR 2 to VR 3 schedules of reinforcement). In cases where only criterion B was met, the immediately preceding pair (of the same type) reaching criterion A was placed on a VR 3 schedule; these responses first were successively placed on FR 1, FR 2, and finally VR 3 schedules.

Probe procedure. To measure generalization of the sequential training of different types of matched responses, a number of nonreinforced (probe) responses similar to those trained (or to be trained) were systematically presented to the subject. These responses consisted of four responses similar to the trained small motor responses, four responses similar to the trained large motor responses, four responses similar to the trained short vocal responses, and an additional four responses, labelled as Long Vocal consisting of words containing consonant sounds preceding and following those vowels used as short vocal probes. The probe responses are listed according to type in the bottom portion of Table I.

Probe responses were first presented in a pretraining session. Thereafter, they were presented within a single session each time a subject reached criterion on a pair of trained responses and was reliably responding on the VR 3 schedule of reinforcement. (As stated earlier, if the subject fulfilled criterion B, the two preceding responses of the same type reaching criterion A were used in the VR 3 schedule to insure some reinforced imitative responding during probe sessions.) Each probe response was presented twice during a session, randomly placed within the VR 3 schedule and replacing one of the nonreinforced responses in the schedule such that no two probe responses followed each other consecutively.

Measurement and Reliability

Each response demonstration was considered a trial. In general, trained responses were scored as correct or incorrect immediately after they were performed, as correct immediately after the experimenter helped the subject, and as incorrect after 10 sec of no response following the demonstration. Probe responses were scored as correct or incorrect only 10 sec after they were performed, or as incorrect after 10 sec of no response following the demonstration. Another response demonstration followed each such scoring. However, during the criterion sessions of vocal training, and for all vocal responses during the probe sessions, responses were recorded on tape and scored later. In these cases, another response demonstration followed 10 sec after the response, or after 10 sec of no response following the demonstration.

In general, correct imitation was defined as a response topography similar to that of the demonstration. In each case of motor behaviors, the boundaries of similar topography were given specific definitions. (For example, "clap hands" required that the palms be touched to one another; "touch knee" required placement of either hand on either knee within 2 in. of the knee cap; *etc.*) In the case of verbal behaviors, as is usual in such studies, similarity was defined by the listener, relying upon apparently widespread language community standards.

At various points during the study, a check by another observer was made of the experimenter's scoring of (1) responses reaching criterion A, (2) maintenance of trained imitations on the VR 3 schedule, and (3) matching of the probe responses. In the case of motor responses, the observer watched from the observation room behind the one-way mirror. The observer was given the definition of the imitations listed in Table I; he then scored simultaneously with the experimenter (and thus was able to see all consequences applied to the subject). In the case of vocal imitations, the observer scored the tape independently of the experimenter (any audible consequences by the experimenter were deleted from the tape).

Criterion reliability was taken at least once for each subject on a pair of imitations of each type. Agreement on the VR 3 schedule was evaluated during the same sessions as probe reliability, by having the observer score all response and reinforcement deliveries. Probe reliability was sampled in the probe sessions listed in Table II for each subject. Reliability in all cases was computed as the percentage of trials scored by both the experimenter and the observer in which they agreed in scoring correct or incorrect imitation.

RESULTS

Reliability

Agreement on the scoring of criterion A for motor responses was always 100%, even though different individuals served as reliability observers. Agreement for vocal responses meeting criterion A, as stated earlier, was procedurally 100% (*i.e.*, 100% agreement was required before proceeding further with the experiment). The reliability assessment during VR 3 phases, for experimenter scoring of trained responses and reinforcement delivery during probe sessions, ranged between 95 and 100%.

Reliability of probe responses is presented in Table II. (Each motor response reliability estimate reflects the percentage of agreement between experimenter scoring and one of four different independent observers. Each vocal response reliability estimate reflects the percentage of agreement between experimenter scoring and one other independent observer.) Percentage of agreement is subdivided into motor and vocal components and presented for each subject by training

Table II
Probe Reliability (% Agreement)

Training Condition	Probe No.	Type of Behavior: Motor	Vocal	Combined
I. Small Motor				
S_2	1	100	100*	100
S_2	4	100	100*	100
S_3	4	100	100*	100
S_4	7	100	100*	100
II. Large Motor				
S_1	7	98	100	99
S_2	7	100	100	100
S_3	7	100	100*	100
S_4	4	100	100*	100
III. Short Vocal				
S_1	9	100	88	94
	10	100	88	94
	11	–	94	–
S_2	9	–	94	–
	10	–	88	–
	11	100	88	94
	12	95	88	90

*Cases where no vocal responses were observed.

condition and probe session. Total reliability ranged between 88 and 100% over all subjects and sessions; those sessions in which no vocal responses were observed are labelled as such.

Training

During motor training, three of the four subjects (S1, S2, and S3) showed some variability in the number of trials required to reach criterion over successive pairs of imitations (a range of 15 to 100). Subject 4 showed extreme variability in learning small motor responses—a range of 15 to 900 trials to criterion. But large motor responses were learned in 15 to 60 trials.

A difference was evident between motor and vocal imitative acquisition for Subjects 1 and 2. The first pair of motor responses for Subject 1 reached criterion A in approximately 100 trials; trials to criterion then decreased to a low of 15 on subsequent pairs of motor responses. Yet, the first pair of vocal responses for this same subject required approximately 3000 trials to meet criterion A, and 900 trials on subsequent pairs (this last number of trials was necessary to fulfill the 15-session criterion B). Similar results were seen for Subject 2: the initial pair of motor responses required 60 trials to meet criterion A, and subsequent pairs ranged between 15 and 30 trials; but 1200 trials were necessary to reach criterion A on the first pair of vocal responses, and each of three following pairs of vocal responses met the 15-session criterion B.

Accurate imitation (close to 100%) of previously trained responses resulted for each subject during the maintenance procedure (that is, when previously trained responses were demonstrated after each pair of currently trained responses reached criterion). Due to this maintenance procedure, previously trained imitations continued to receive reinforcement throughout the study.

Probes

Because of subject variations, probe results (imitation of responses never trained) are presented individually for each subject. Figures 1, 2, 3, and 4 represent these probe data respectively for Subjects 1 through 4. The number of correct probe trials is plotted over successive probe sessions. In each probe session, eight probe responses of each defined type were demonstrated (four of each type, each response demonstrated twice); the score presented is the number of these eight responses imitated. Vertical arrows over bars indicate that responses similar to these probes were undergoing training at that time. X's over bars indicate that responses similar to these probes had been trained earlier. Imitation of the two trained responses on the VR 3 schedule during probe sessions was always over 95%.

Subject 1 (Fig. 1). In the pretraining session, no demonstrations were imitated. During small motor training, small motor probe imitation increased gradually over the four successive probe sessions. No systematic change was seen for other types of probe responses. Increased imitation of large motor probe responses occurred during the training of large motor responses. Small motor probes continued to be imitated at the level attained during small motor training. Vocal probes were never imitated until short vocal training was instituted. At that time a gradual increase of short vocal probe imitation resulted, but no long vocal probes were imitated. The two types of motor probes continued at their previous levels. Consequently, the increased imitation of probes was restricted to responses similar to those receiving training. The num-

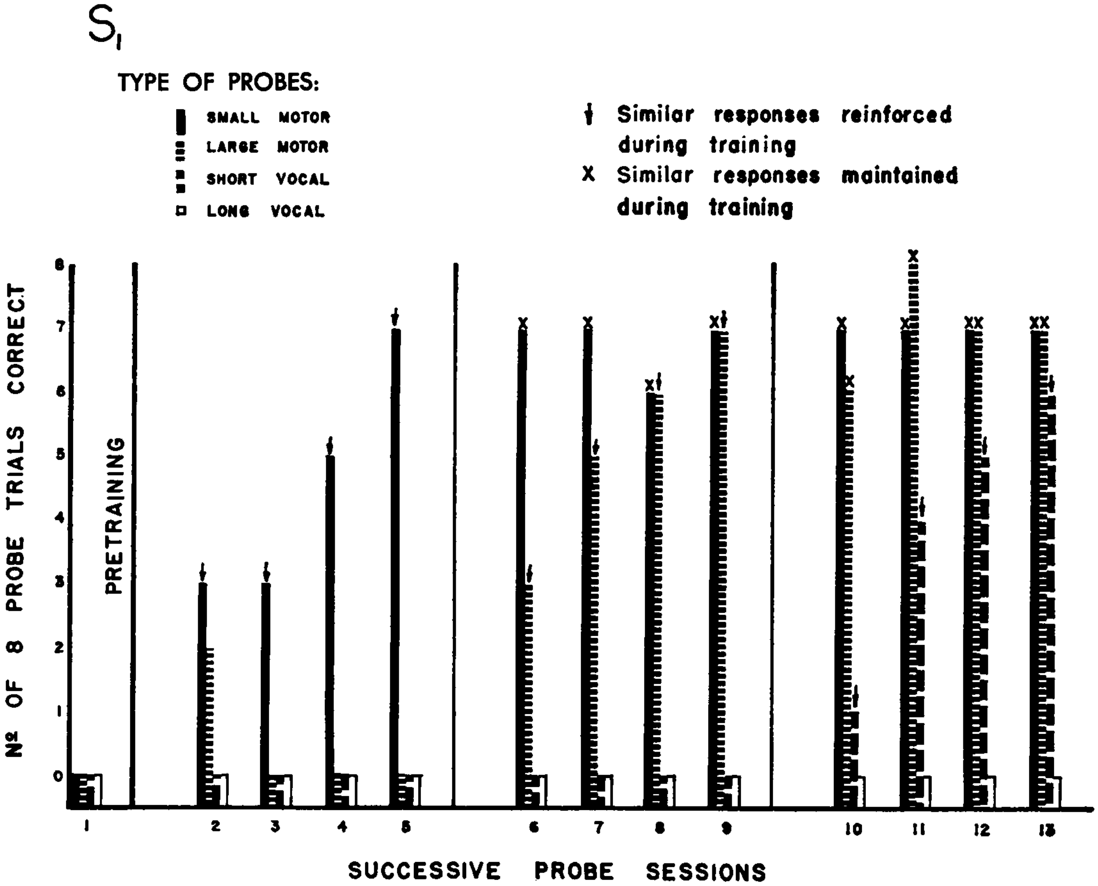

Fig. 1. Number of eight probes of each topographical type imitated by Subject 1 over successive probe sessions.

ber of imitated probe responses increased as a greater number of similar responses were trained and for each motor type, the level of imitation remaining the same throughout subsequent training of different types.

Subject 2 (Fig. 2). The same restricted pattern of probe imitation was seen in Subject 2. Differences from Subject 1 were apparent during the pretraining probe session, in which Subject 2 imitated four of the small motor probe responses; and during small motor training, as Subject 1 consistently matched one or two large motor probe responses. Successive small motor training doubled small motor probe responding over its pretraining level, and large motor training increased large motor probe responding to three times its level during small motor training. Vocal probe imitation remained at zero until short vocal imitations were trained. During short vocal training, an increase in the imitation of short vocal probes resulted; long vocal probes always remained at zero imitation. Thus, restricted generalization of probe imitation was evident in both subjects: increased probe imitation was always a close function of the type of responses undergoing training.

Subject 3 (Fig. 3). Only motor responses were trained in this subject, but a different training order was followed (large motor, then small motor). During the pretraining session probe responses were not imitated. Successive training of large motor responses produced an increased imitation only in this same type of probe responses. The small motor training that followed resulted in an increase of small motor probe imitations. This increase in probe imitation occurred only for responses that were similar to those receiving training.

Subject 4 (Fig. 4). Subject 4 became a special case because of the little generalization occurring during small motor training. This result is shown in Fig. 4. There was no imitation during the pretraining probe session. Responding to small motor probes increased during small motor training, but the increase was not as substantial as for previous subjects. For this reason, further training continued on small motor responses. This extensive training had no effect on small motor probe imitation. The subsequent procedure of large motor training produced an increase in imitation of large motor probes; however, the number of small motor probes imitated remained at the same level as they had during small motor training.

Examination of Table I for the trained small motor responses reveals that each pair of responses (except the last two) consisted of two topographically different types: (A) "non-body" responses requiring manipulation or hitting of objects and (B) "body" responses requiring touching different parts of the body. The four small motor probes can also be subdivided into these two topographical types (two of each). Figure 5 shows the number of four possible probe matches for each of these two types during successive probe sessions. The result indicates a consistent imitation of "non-body" probes (three or four of the four possible) accompanied by non-imitation of "body" probes (zero or one of the four possible).

DISCUSSION

The development of an imitative repertoire was observed in each subject. Initially nonimitative subjects were trained to imitate by a technique that provided specific consequences for responses that matched those demonstrated by a model. This training concurrently produced response matching, which

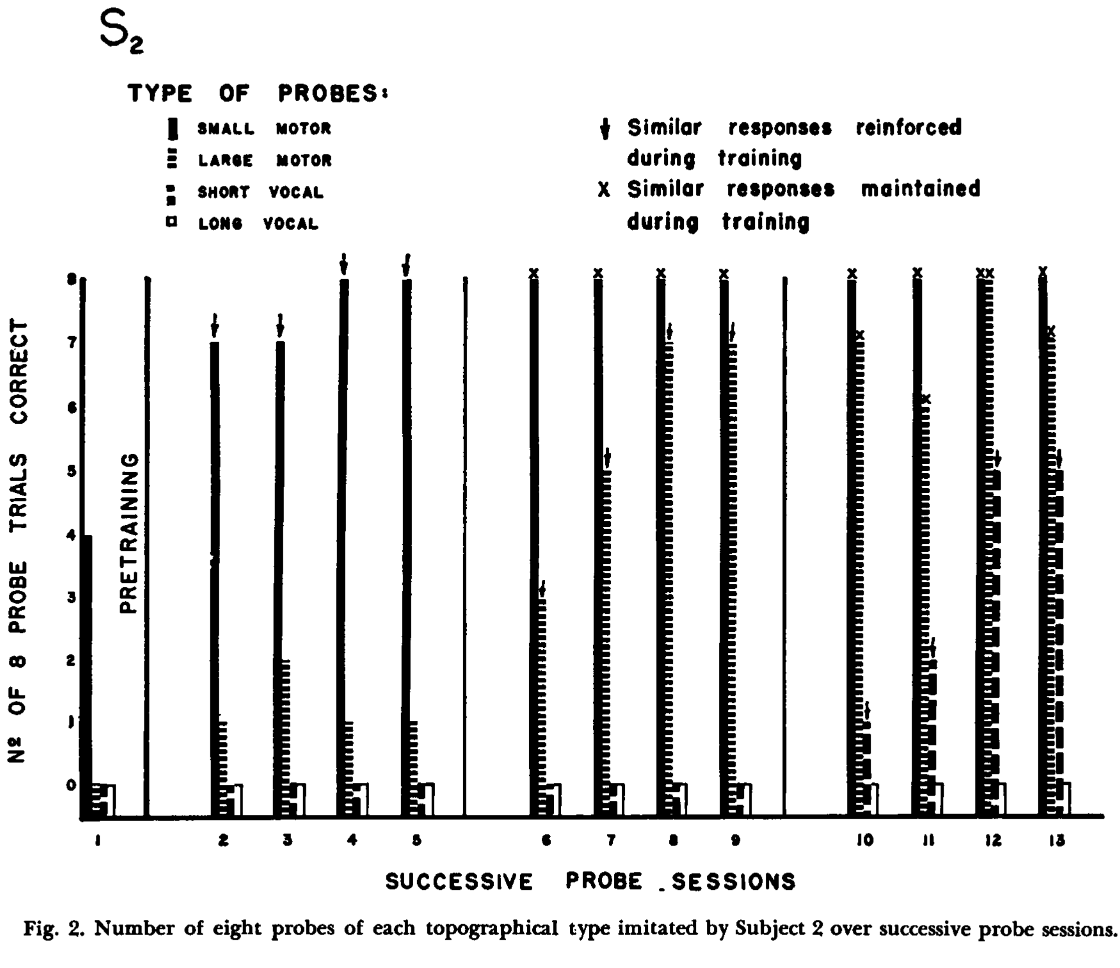

Fig. 2. Number of eight probes of each topographical type imitated by Subject 2 over successive probe sessions.

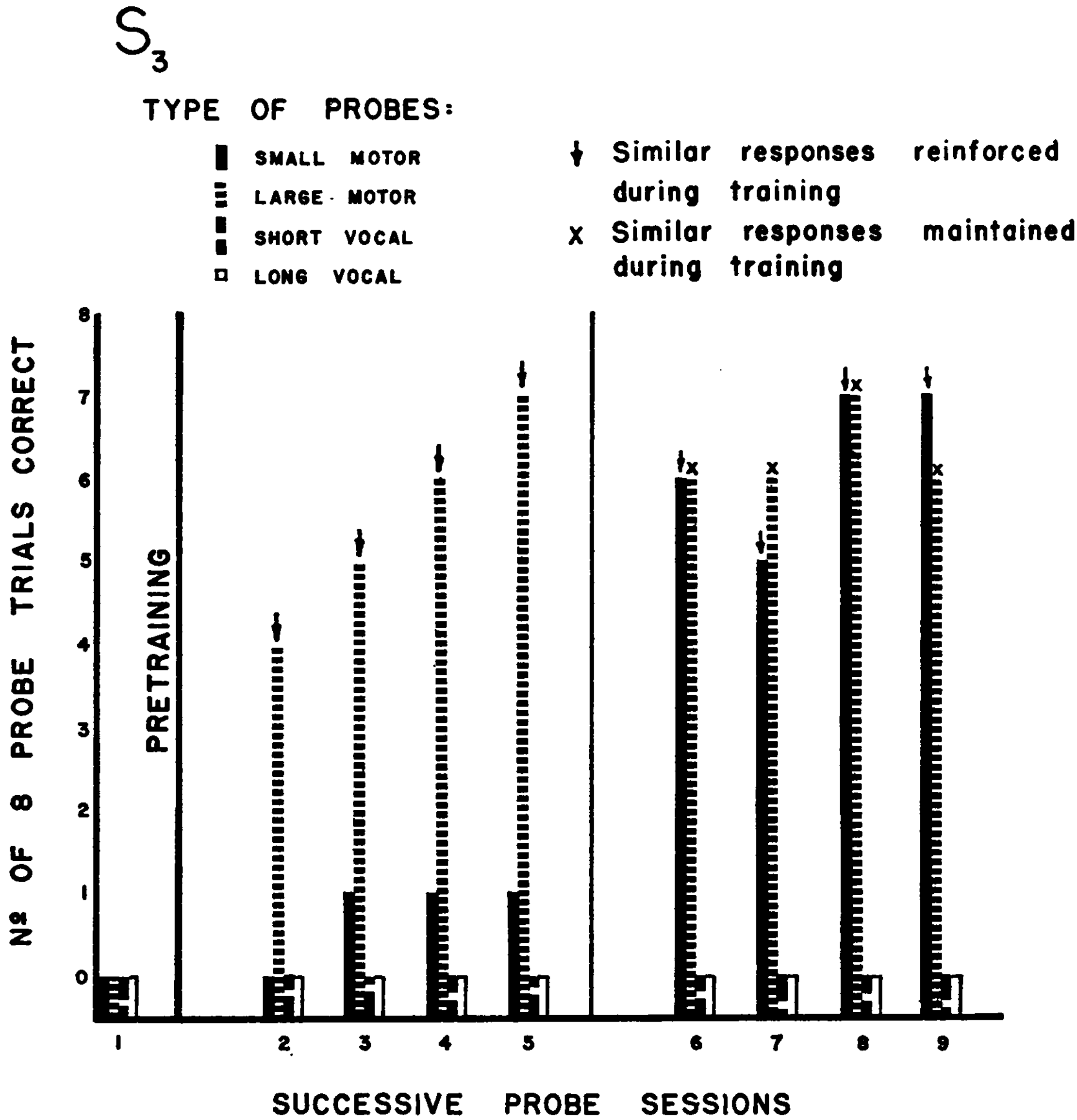

Fig. 3. Number of eight probes of each topographical type imitated by Subject 3 over successive probe sessions.

was never followed by any specific stimulus consequence. It is this generalization of response matching that leads to the conclusion that an imitative repertoire was established—a generative matching skill. This generalization also ties these particular sets of imitations to the general concept of an imitative response class described by Metz, Lovaas *et al.*, and Baer *et al.* These investigators reported a functional relationship between the reinforcement of and the generalization of imitation.

However, a topographically restricted generalization of imitation resulted from the present training procedures. This restriction was controlled by the recent training history of imitative response topographies in all four subjects. The multiple baseline technique demonstrated that imitation of similar topographical responses remained unaffected until training was instituted for responses representative of these types. Thus, for each topographical response type, a topographically corresponding imitative response class was demonstrated. The demonstration of distinct imitative response classes in S_1 and S_2 was particularly evident between motor and vocal imitation. Vocal response probes were never imitated during motor imitation training, and the number of sessions and trials required to train motor imitations were much fewer in number. But within motor responses, distinct generative imitative repertoires were established in all subjects (small motor *vs* large motor).

The acquisition and generalization of imitation were accomplished by a training technique in which imitation of a model was followed by a stimulus consequence. The role of this stimulus consequence as a reinforcer was not tested in this study. However, the training procedures resembled those used by Baer *et al.* (1967) who did demonstrate the reinforcing function of the stimulus consequence. That suggests a similar reinforcing function of the present stimulus consequences. Clearly, the training procedures as a whole functioned to produce distinct generalizations of imitation (one baseline at a time).

Certain constraints should be considered. For example: in this study training was continued for approximately 80 hr per subject: each subclass of imitation received training for some fraction of these 80 hr. Longer training of each subclass might have produced different generalization.

Another constraint lies in the choice of responses for training and probing. A different assignment of specific responses to the training contingencies, or a different make-up of the probes, even within the topographical subclasses chosen for study, might have yielded different results. Finally, the use of a severely retarded subject population is an obvious constraint on the generality of the results. However, the subjects were purposely chosen for their retardation, specifically their lack of imitation. The generality of these results therefore depends on further research of this type in normal children who have not yet devel-

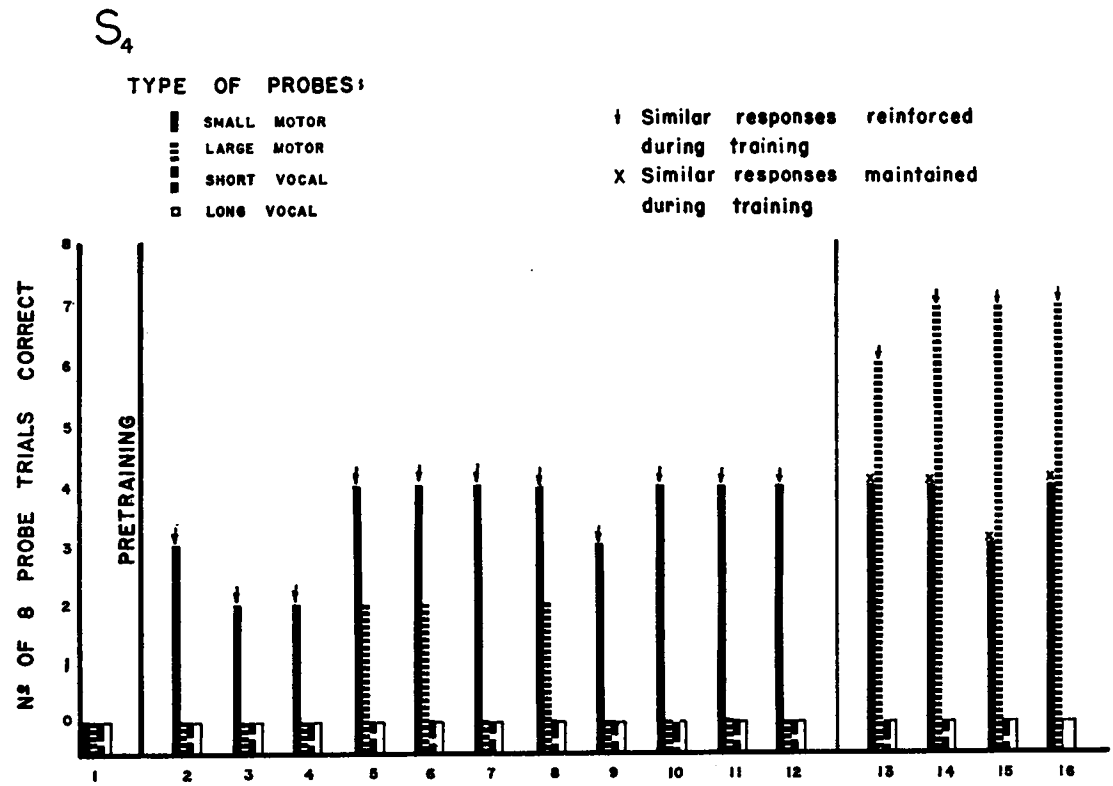

Fig. 4. Number of eight probes of each topographical type imitated by Subject 4 over successive probe sessions.

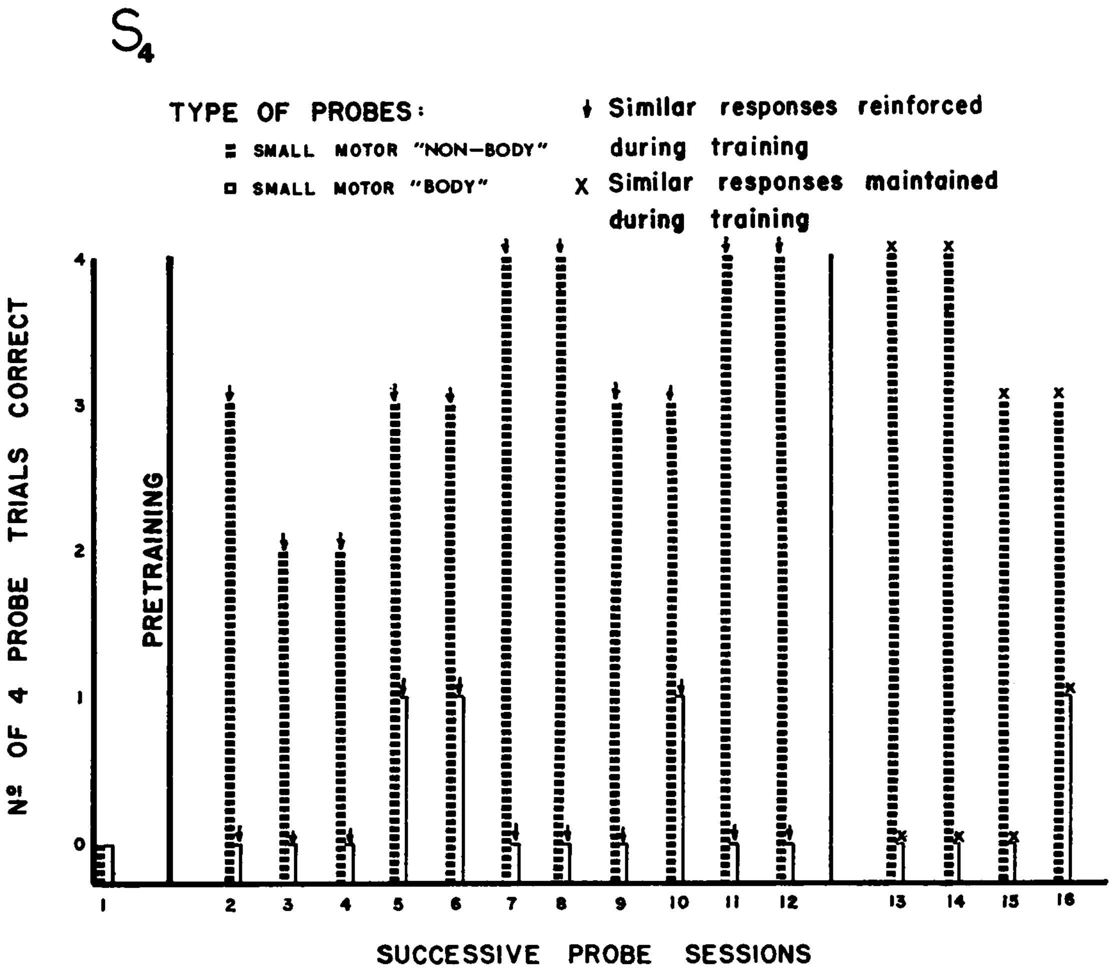

Fig. 5. Numbers of four probes of small motor "non-body" and four probes of small motor "body" imitated by Subject 4 over successive probe sessions.

oped an imitative repertoire. But, like any study utilizing normal or retarded subjects, the relationship of its results to the development of imitation depends largely on the assumption that the subjects did not imitate previously. Pretraining observations reported earlier confirm, to some degree, the non-existence of an imitative skill in these subjects. Whether in fact these observation were sensitive to this measure is a relevant question. It is possible that they were not; if so, the data represent a systematic "rediscovery" of imitation, or some similar phenomenon, but do not pertain to the initial development of imitation. However, accepting such constraints does not negate the empirically demonstrated relationship concerning the topographical limits of generalized imitation.

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