TRAINING GENERALIZED IMPROVISATION OF TOOLS BY PRESCHOOL CHILDREN¹

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The development of new, "creative" behaviors was examined in a problem-solving context. One form of problem solving, improvisation, was defined as finding a substitute to replace the specifically designated, but currently unavailable, tool ordinarily used to solve the problem. The study examined whether preschool children spontaneously displayed generalized improvisation skills, and if not, whether they could be trained to do so within different classes of tools. Generalization across different tool classes was monitored but not specifically trained. Five preschool children participated in individual sessions that first probed their skill at improvising tools, and later trained and probed generalized improvisation in one or more of three tool classes (Hammers, Containers, and Shoelaces), using a multiple-baseline design. All five children were trained with Hammers, two were trained in two classes, and two were trained in all three tool classes. Four of the five children improvised little in Baseline. During Training, all five showed increased generalized improvisation *within* the trained class, but none across classes. Tools fabricated by item combinations were rare in Baseline, but common in Training. Followup probes showed that the training effects were durable.

DESCRIPTORS: creativity, problem solving, improvisation, training, generalization, preschool children

Nonbehavioral approaches to the training of creativity and problem-solving skills have been applied in industrial and educational settings (*e.g.*, Gordon, 1961; Parnes, 1975; Torrance, 1975) with varying degrees of success (Davis, 1973; Torrance, 1972). Some proponents of these approaches have been critical of behavior analysis, questioning its capacity to contribute to the development and maintenance of creative behaviors (Cole and Parsons,

1974; Crary, 1969). However, recent studies have used behavioral principles to increase the diversity of forms made by children in activities such as written expression (Ballard and Glynn, 1975; Brigham, Graubard, and Stans, 1972; Glover and Gary, 1976; Maloney and Hopkins, 1973), and blockbuilding and easel painting (Goetz and Baer, 1971, 1973; Goetz and Salmonson, 1972; Goetz, Jones, and Weamer, Note 1; Holman, Goetz, and Baer, 1977). The present series of studies provided convincing evidence of the fact that, in artistic activities, behavioral diversity and the production of novel forms can be strongly responsive to environmental contingencies. Thus, these studies begin a research enterprise that might provide important information on processes relevant to the establishment of those novel functional behaviors often labelled creative (Baer, Rowbury, and Goetz, 1976; Bijou, 1976; Holman *et al.*, 1977). More data are required to show which classes of behaviors are responsive to such training, their durability after

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training, and the extent to which they generalize or can be made to generalize.

An interesting class of behaviors outside the realm of artistic activities is problem solving. Skinner (1953, 1969) proposed that problem-solving behaviors were operants, and thus amenable to functional analysis and responsive to environmental contingencies. In elaborating on Skinner's proposition, Bijou (1976) provided a functional definition of problem solving: interactions when an individual, who has no immediate response that produces reinforcers, systematically modifies the situation in order to generate a reinforceable response. To do so may involve manipulation of physical, social, or personal phenomena, or of abstract relations. Skinner (1953) and Bijou (1976) both differentiate between systematic problem solving and unsystematic trial-and-error or chance solutions (which they do not regard as problem solving). However, trial-and-error behavior presumably could serve as a precursor of systematic problem solving, by increasing the sampling of the essential discriminations involved in the solution. Then, systematic refinements that produced the most effective means of solution might follow.

To reach a solution, the individual must have the appropriate behaviors in repertoire (Bijou, 1976). One such class of behaviors appropriate to interactions with physical objects, is improvisation. This involves finding an effective, possibly unconventional, substitute to replace some specifically designed but currently unavailable item (*e.g.*, in an emergency, an effective automobile fan belt can be improvised from a woman's nylon stocking). The process of improvisation involves identifying the essential characteristics of the unavailable item, and then searching for the effective alternative. Such items sometimes might have to be adapted from unlikely alternatives; thus diverse and novel forms of problem solution would be valuable skills. Since production of diverse and novel forms of artistic behavior has been shown to be responsive to systematic behavioral pro-

gramming, it is possible that diverse, novel forms of problem solution are similarly responsive. And childhood might be a good time to train such skills.

Children, in their interactions with the environment, occasionally are confronted with mechanical problem-solving situations. For example, a wheel may fall off a toy, and, if play is to continue, require repair. Frequently, children do not have access to appropriate tools. However, a resourceful child might search the environment for a suitable alternative tool. This ability to behave resourcefully was considered to be of sufficient personal and social value to children that the possibility of training generalized improvisation was deemed worthy of systematic investigation.

Stokes and Baer (1977), in an extensive review of generalization research in applied behavior analysis, identified and classified nine generalization-programming techniques, two of which were selected for application to the establishment of generalized improvisation in the present study. The first technique was identified in the Stokes and Baer taxonomy as *Train sufficient exemplars*. The essence of this procedure is first to teach one example of a generalizable lesson and then probe for evidence of generality: if there is none, then teach another exemplar and probe again, repeating this process until the sought-after generalization is sufficiently established. The second generalization technique was labelled *Train to generalize*. If generalization is conceived of as a skilled behavior, then in principle it can be consequated by contingent reinforcement. The descriptive social reinforcement of the production of diverse forms, employed in the studies by Goetz and her associates, is an example of this procedure, in that only advances along the generalization gradient were consequated. Combination of these two procedures was considered potentially advantageous in the present study, to the extent that generalized improvisation could be promoted by exposure to a diverse array of training exemplars and consequated

by descriptive praise, thus maximizing the likelihood of the development of diverse problem-solving behaviors.

In the present study, diverse, novel, generalized improvisations in each of the problem tasks were facilitated by exposure to a diverse array of unlikely, but potentially functional exemplars. Then, once a novel generalized improvisation was made, it would produce contingent descriptive praise on that occasion, but not thereafter.

Thus, the aims of the study were to establish (1) whether preschool children spontaneously displayed diverse improvisation skills; (2) if they did not, whether they could be trained to display diverse, novel, generalized improvisation of tools in each of three problem tasks; (3) and if so, whether the generalized improvisation skills established by training in one problem task area would generalize further to other, as yet untrained, task areas.

METHOD

SUBJECTS AND SETTING

Five children attending the morning program at University of Kansas laboratory preschools participated in the study. Four were male (one black, three white) and one was a white female. Three of the children were normal 3-yr-olds; two, Luther (5 yr) and Ronnie (6 yr) were staying on in preschool for the purposes of remediating language and behavioral problems.

Individual, 15-min experimental sessions were conducted once daily four days per week, in a 2.44-m by 1.38-m research room adjacent to the preschool classrooms. It was carpeted and furnished with a small table holding experimental materials, and had a one-way screen along one wall that permitted independent observation from an adjoining booth.

Equipment and Performance Criteria

There were three tasks: pounding on a pounding toy, storing marbles, and lacing a

shoe. Each task required the improvisation of its respective tools: *i.e.*, of hammers, containers, and shoelaces. Each task's materials included exemplars of its possible tools, which were used to perform the task before generalization probes, and a further pool of probe objects, some of which could be improvised as effective tools, the rest serving as distractors, in that they could not be used successfully as tools (at least, not within the limits of the experimenter's ability to improvise). Examples of these materials are provided in Table 1 and a general outline of the equipment is provided below.²

Hammers. The Hammer task was to pound down the wooden pegs on a Cobbler's Bench toy (Playskool). An effective hammer was defined as any item that enabled the user to pound at least one of the pegs to within 3.2 mm of the bench-top. The exemplar used throughout Baseline sessions was a wooden, toy claw-hammer. Training exemplars ranged from relatively conventional alternatives (*e.g.*, a tack hammer) to unlikely combinations such as a piece of rod and a 35-mm film cannister. The pool of potentially effective probe objects consisted of seven items that, when used alone, (*e.g.*, a piece of brick) or in combination (*e.g.*, drilled block and rod), served as hammer substitutes. The 10 distractor probe items, which included some that had the appearance of effective alternatives (*e.g.*, a styrofoam claw-hammer), were not capable of pounding the pegs down when used alone.

Containers. The Container task required putting 80 marbles in any container in which they could all be carried without loss. The Baseline exemplar was a 20.3-cm by 26.7-cm paper bag. Training exemplars varied from a plastic bag to a cardboard tube, one end of which could be blocked with paper. The six potentially effective probe items included single items (*e.g.*, a glove) and item combinations,

²Details of all equipment, exemplars, and improvised tools are available from the first author.

such as a bottomless 240-ml styrofoam cup, the bottom hole of which could be blocked with a variety of items such as a facial tissue or a cup-cake cup. Distractor probe materials included items that appeared effective, but were not (*e.g.*, a torn paper bag), and others that were too small to be useful when used alone (*e.g.*, a 90-ml paper cup).

Shoelaces. Shoelaces were defined as those items that could be threaded through at least two pairs of adjacent eyelets on a child's shoe, and could be drawn tight and tied. The children were not required to tie the lace. (None of the children could thread the shoe correctly with the exemplar lace in the initial baseline session. They were subsequently trained to do so by the use of physical and verbal prompts, which were faded progressively as proficiency increased). The exemplar used in Baseline was a 45.7-cm brown shoelace. Training exemplars included string, plant-tie wire, and folded masking tape. Probe materials consisted of five potentially useful items (*e.g.*, a pipe cleaner, a hank of embroidery thread from which a "lace" could be cut), and 10 distractor items such as a freezer-bag tie and a drinking straw.

Behavioral Definitions

Three response classes relating to use of probe items were defined as follows:

Pick-up (P). Pick-ups involved removal of any item from the tray on which they were presented, without any attempt being made to use them as a tool for the task at hand before they were put down.

Attempt (A). An Attempt was scored when any item was used in a manner appropriate to the relevant tool, but failed to meet the criteria of successful performance.

Improvisation (I). An Improvisation was recorded when an item or combination of items was used so that the relevant performance criteria were met. Two classes of Improvisation were identified: (a) Simple improvisations, which involved the use of an item in its original, unmodified form to perform the required

task; and (b) Complex improvisations, in which an effective tool was produced either by assembling or combining two or more components to form an effective unit, or by adapting an originally unusable item so that it became a useful alternative. Theoretically, distractor items could have been reclassified as improvised tools if used alone to perform the task to criterion. This did not happen, although some distractor items were successfully used in conjunction with potentially effective probe items to produce complex improvisations of Hammers and Containers.

Recording Procedures and Reliability

For the purposes of recording, the following conventions were adopted: (a) The three response classes were accorded different values. Pick-ups were regarded as being the lowest form of interaction with the probe items because they did not involve their use as tools. Attempts were of a higher order, in that they involved attempted use of items as tools. Improvisations represented the highest order of interaction with probe items. (b) When, in each session, the first interaction with any item(s) was scored as being either a Pick-up or an Attempt, that interaction was superceded in the record by the first of any subsequent interactions in that session with that same Tool or Distractor that were of a higher order, *i.e.*, an Attempt superceded a Pick-up, and an Improvisation superceded an Attempt. (c) Once the first Improvisation of any item(s) was recorded in a session, further interactions, either at the same level or at a lower level, were not recorded when they involved the same Tool being employed in the same way. Attempts or Improvisations that subsequently re-employed the same item(s) in novel or different ways were recorded on their first occurrence.

Thus, the data of each session showed which item(s) had been interacted with at least once, and the highest level of interaction in the session.

For recording purposes, all probe items on the trays were allocated individual code sym-

Table 1
Examples of Materials Used as Task Materials, Exemplars, Probe Items, and Distractors in the Three Tool Classes

Tool Class		HAMMERS	CONTAINERS	SHOELACES
Task materials		Cobbler's Bench (Playskool)	80 Marbles	Child's shoe
Baseline exemplar		Wooden toy clawhammer	Paper bag	45.7-cm shoelace
<i>Training exemplars</i>				
a) Simple improv.		Adjustable wrench Child's small shoe Broken tree branch	Margarine tub Nylon sock Large party balloon	yellow ric rac Nylon fishing line Plant-tie wire
b) Complex improv. (Type I)		Wood offcut + rod Comb. wrench + rod Alphabet block + rod	Cardboard tube + foil Cardboard box (with hole) + paper Plastic mesh tub (with hole) + Xmas wrap	Hank of plastic thonging
c) Complex improv. (Type II)		Drilled rubber spacer + rod Tinkertoy wheel + axle Tinkertoy pulley + axle	26.6 by 26.6 cm brown paper 22.8 by 22.8 cm paper towel 27.9 by 27.9 magazine page	Bulky knitting yarn Twisted strands of string
<i>Probe items</i>				
a) Simple Improv.	Item	Code letter	Item	Code letter
	Wood offcut	a	Frisbee	Pipe cleaner a
	Screwdriver	c	Glove	Ribbon b
	Piece of brick	g	Hat	Flex c
b) Complex Improv. (Type I)	Piece of brick + long rod	P	Bottomless styro-cup + foil	Embroidery thread D
	Cotton spool + long rod	Q	Bottomless styro-cup + Kleenex	
c) Complex Improv. (Type II)	Drilled block + long rod	H	Strip of foil	
	Drilled block + short rod	I	Newspaper insert	Frayed nylon rope E
<i>Distractors</i>				
	Styrofoam clawhammer		3 fl. oz paper cup	Xmas tree tinsel
	Small stone		Kleenex tissue	Wide ribbon

bols. Simple improvisation items were identified by lower-case letters, distractor items by lower-case Roman numerals. Because the precise form of all complex improvisations could not be predicted in advance, observers recorded the code letters/numerals of the individual components of any new combination when it was produced and, later, it was allocated its own identifying upper-case code letter. In this way, interobserver agreement could be achieved on the form of novel complex improvisations. As an aid to accurate recording, each observer had a list detailing individual probe items and their respective code letters/numerals. As new improvisations were produced, their code letters were added to the observers' lists.

The experimenter (B.S.P.) served as the primary data recorder. Reliability checks were made by a second, experienced observer who was located behind a one-way screen in an adjoining observation booth. This observer was aware of the general aims of the study. Data on interobserver agreement were obtained in all phases of the program and on over 50% of experimental sessions.

Overall percentage (range in parentheses) of interobserver agreement on the probe items interacted with, and the response class of that interaction over each session, for each subject, were as follows: Elsie, 96% (73 to 100%); Jerry, 92% (67 to 100%); Jimmy 93% (67 to 100%); Luther, 97% (80 to 100%); Ronnie, 97% (70 to 100%). Interobserver agreement on response class attributed to probe items from each of the three tool classes was also calculated for each of the subjects. Overall percentages (range in parentheses) relating to the most relevant category, Tools Improvised, were: Hammers, 99.5% (98 to 100%); Containers, 99.6% (97 to 100%); and Shoelaces, 100%. When they occurred, low interobserver agreements usually accompanied disagreements over the occurrence of very low-rate behaviors. For example, the lowest overall percentage agreement occurred in the category Tools Attempted, for Shoelaces (83.8%, range 0 to

100%). The 0% resulted from disagreement between observers over the occurrence of the one and only response made by Jerry that could have been scored as an attempt at improvising a shoelace.

EXPERIMENTAL DESIGN

The major goal of the study was to establish whether or not active generalization training procedures could be used to increase the improvisation skills of preschool children. To achieve this, a series of concurrent experiments was conducted. The total program of Baseline, Training, and Followup conditions of each subject in each task is shown in Table 2.

Within-subject Multiple Baselines

The within-subjects baselines served a dual purpose. First, in the program of each subject, the multiple baselines were used to monitor generalization of improvisation skills across tool classes: for each subject, the training was introduced sequentially into certain baselines while the remaining baselines, as yet untreated, were monitored for generalization. Thus, Elsie was trained only on the Hammers task; her baselines in the other two tool classes were monitored for generalization across tool classes for the remainder of the study (see Table 2). Jerry and Jimmy were, at first, sequentially trained on Hammers; meanwhile, their two remaining tool classes were probed for possible generalized improvisation. Subsequently, the training procedure was interpolated into a second baseline of each child. A similar sequence was adopted for Luther and Ronnie, both of whom subsequently were trained on all three tool classes, as shown in Table 2. Second, these same within-subject multiple baselines were employed to explore the relationship between the training procedure for a given task and the resultant increased production of new improvisations within that task's tool class. The training procedure was introduced sequentially to different tool classes so that, as Table 2

Table 2

Program of Experimental Conditions for Each Subject within the Three Tool Classes

Subject	Tool Classes (in Order of Training)	Sessions Covered by Experimental Phases		
		Baseline	Training	Followup
Elsie	1. Hammers	1-24	25-44	45-48
	Shoelaces	1-48	Not trained	No followup
	Containers	1-48	Not trained	No followup
Jerry	1. Hammers	1- 4	5-32	33-38
	2. Containers	1-14	15-32	33-38
	Shoelaces	1-32	Not trained	33-38
Jimmy	1. Hammers	1-14	15-32	33-38
	2. Shoelaces	1-21	22-32	33-38
	Containers	1-32	Not trained	33-38
Luther	1. Containers	1-11	12-50	51-62
	2. Hammers	1-19	20-50	51-62
	3. Shoelaces	1-35	36-50	51-62
Ronnie	1. Containers	1-34	35-52	53-62
	2. Hammers	1-39	40-58	59-62
	3. Shoelaces	1-46	47-62	No followup

shows, Jerry and Jimmy were trained sequentially in two tool classes, and Luther and Ronnie were trained sequentially in all three tool classes.

Between-Subject Multiple Baselines

First, in order to establish the generality of the training procedure across all subjects, and to demonstrate the relationship between sequential exposure to the training procedure and generalized improvisation within that tool class, all five children were trained sequentially on the Hammers task. Second, to establish the generality of the training procedure in each of the remaining tool classes, Containers and Shoelaces, Luther and Ronnie were paired in a between-subjects multiple-baseline design.

PROCEDURE

Baseline

Each child was escorted from the preschool classroom to the research setting by the experimenter. On entering the experimental room, both the experimenter and the child sat (or knelt) on the floor, which provided a more

suitable work space than the table (especially because of the marbles, which easily rolled off the table top). The first of the day's three tasks was then introduced, along with a description and a demonstration, using the Baseline exemplar tool, of criterion performance by the experimenter. (Much of this introductory procedure was faded in subsequent sessions as the children became familiar with the equipment, leaving a core of standardized instructions telling the child, in effect, to accomplish the performance criteria described in the Equipment and Performance Criteria section). The child was then given the exemplar tool and invited to perform the task to the same criterion. Verbal encouragement to complete the task to its criterion was given, and successful completion was accompanied by descriptive feedback and praise (e.g., "Good girl! You have hit the peg right down with the hammer.").

An improvisation probe trial followed immediately. It was introduced by the withdrawal from sight of the exemplar tool, and a suggestion that the child act as though the exemplar tool was no longer available. The probe items were then presented on a tray and the child invited to find something with which to

perform the task to criterion (*i.e.*, in the Hammers probe, the instruction was as follows: "Look at the things on the tray and find something that you can hit a peg right down with."). If, after 15 sec, no attempt had been made to pick up any probe items, this invitation was repeated. If a further 15 sec elapsed with no response, the trial was terminated and the next tool class introduced.

When a child used a simple or complex probe item successfully, the fact that criterion had been reached with that particular item was immediately pointed out in a matter-of-fact manner (*e.g.*, "See, you hit that peg all the way down with the cotton-spool."). Repeated use of an item was permitted, but no comment was made following its subsequent effective uses. Unsuccessful attempts with either potentially effective or distractor items were not followed by comment.

Once subjects put down an item they had been using or inspecting, they were encouraged to find something else on the tray that they could use to perform the task successfully. The trial continued in this fashion until the child announced completion, or until 4 min had elapsed since introduction of the exemplar tool.

Each succeeding tool class was introduced immediately after the probe trial of the preceding tool class was terminated. The conventional exemplar tools of all three tool classes were presented, and improvisation probed in the above fashion, in each Baseline session. For three subjects, the order of presentation was Hammers, Shoelaces, and Containers; for two, that order was reversed.

At the end of each session, the child was given a small toy as a reward for attending, which was not contingent on performance in the session. The child then was returned to the preschool classroom by the experimenter.

Training

The Training procedure differed from that of Baseline in two important respects, each of

which was associated with the generalization training strategies of training sufficient exemplars, and training to generalize (Stokes and Baer, 1977).

Training sufficient exemplars. Whereas in Baseline the same, conventional, exemplar tool had been used in each session, in the Training phase a different, usually unconventional, exemplar tool was introduced in each session. The presentation of the initial series of 10 exemplars was programmed in each tool class as follows: the first three exemplars represented relatively conventional alternative tools, which served to exemplify diverse, yet simple adaptations. These were followed by five diverse and unconventional exemplars of simple adaptations. Then, the last two exemplars each demonstrated a different type of complex improvisation. If, when this sequence was completed, there were any types of improvisation that had not been made, or for which further variations could be produced, additional relevant exemplars were presented until either the child showed evidence of generalization, or the supply of exemplars was exhausted. This additional training was an *ad hoc* procedure, because it was not possible to anticipate the number of exemplars that might prove sufficient to establish generalization of any particular improvisation. Although the Training exemplar tools demonstrated general principles that could be applied in using the probe items, they did not closely resemble those items.

Training to generalize. In the Training condition, both contingent praise and descriptive feedback were given following the first successful novel improvisation (simple or complex) of a probe item (*e.g.*, "Good boy, you hit the peg all the way down with the piece of brick. That's great!"). Repeated use of a newly improvised item within that same session generated no comment. Its re-use in subsequent Training-Phase sessions was noted only on the first occasion in any session, and then only in the form of descriptive feedback (without praise) on reaching criterion.

For each subject, the Training procedure was introduced sequentially into the baseline of various tool classes, in accordance with the multiple-baseline designs outlined previously.

Followup

Followup probes documented the performance of subjects after training was terminated. The procedures were similar to those employed during Baseline, except that exemplars were omitted—only probe trials were conducted. The children were presented with the tray of probe items and invited to find something they could use to complete the task to criterion. Descriptive feedback was given following the first occurrence of any improvisation within a session, including any new improvisations (for which no praise was given). All three tool classes were presented in each session.

For three subjects—Elsie, Luther, and Ronnie—followup probes were introduced in sessions immediately following termination of training, and continued for up to 12 sessions. Jerry and Jimmy, who were not available for continued training during the summer or fall sessions, were each followed up for six sessions in the fall, some three months after termination of their training.

RESULTS

The improvisation data have been presented using cumulative step charts, each step indicating the first occasion on which criterion was reached using a new tool. The newly improvised tools are identified by the code letters enclosed within the limits of the step; lower-case letters identify simple improvisations, upper-case letters identify complex improvisations. The maximum number of improvisations in each tool class (*i.e.*, 24 Hammers, 14 Containers, 5 Shoelaces) shown on the ordinates were derived *post hoc* by the experimenter and represent the limits of his capacity to improvise effective tools from the probe and distractor items.

Within-Subject Data

Figure 1 represents data on Elsie's generalized improvisation within and across tool classes. She was trained only on Hammers, both Containers and Shoelaces being monitored for generalization across tool classes.

Training increased the number of successful new (*i.e.*, generalized) improvisations of hammers eight-fold. No complex improvisations were made during Baseline, but three were produced during the Training condition. The 15-week summer vacation, which occurred during the Training phase, did not appear to have any detrimental effect on the training process. Followup produced one further new improvisation, as well as re-use of a wide variety of those previously employed.

Ongoing Baseline data on both Containers and Shoelaces showed no generalization of improvisation skills across tool classes following Hammer training.

Both Jerry and Jimmy (see Figure 2) were trained in two tool classes, Jerry in Hammers and Containers, Jimmy in Hammers and Shoelaces. In each case, the untrained tool class was monitored for generalized improvisation across classes.

The effect of introducing the training procedure into the Hammers baseline is apparent for both Jerry and Jimmy, the respective changes in the number of new, generalized improvisations made in Baseline and Treatment phases being from zero to six and from two to four. Jerry made no complex improvisations in Baseline and two during Training. Jimmy produced one in each phase. Over Followup, which was instituted 15 weeks after training terminated, Jerry made one new, simple improvisation, and both subjects re-used a variety of previously improvised items.

In the absence of generalized improvisation skills across tool classes following introduction of Hammer training, the Training procedure was subsequently introduced into each of these subjects' second baseline. Data in Figure 2

Fig. 1. Cumulative new tools improvised in Baseline, Training, and Followup probes by Elsie. The letters indicate a given tool, when it was first improvised, and its degree of complexity (lower case = simple improvisation, upper case = complex improvisation). Hammer Training was interrupted by a 15-week summer vacation.

show only small evidence of a training effect for both subjects, the change in number of new improvisations between Baseline and Training phases being from one to two for Jerry (Containers) and from zero to one for Jimmy (Shoelaces). Jerry produced one complex improvisation during the Training phase and Jimmy achieved one in Followup. There

Fig. 2. Cumulative new tools improvised by Jerry (left) and Jimmy (right) in Baseline, Training, and Followup probes. (A 15-week summer vacation intervened between Training and Followup.)

was no indication of subsequent generalization of improvisation into the third, untreated, baseline of either subject.

Figure 3 shows the data for both Luther and Ronnie, who received training on all three tool classes, in the order Containers, Hammers, and Shoelaces.

For both subjects, the effect of introducing training into the Containers baseline was to increase the number of new, generalized improvisations, from one to six for Luther and from three to eight for Ronnie. Ronnie increased his output more dramatically than did Luther. Both subjects increased complex improvisations during training, Luther making none in the Baseline condition and four in Training, and Ronnie none in Baseline and eight during Training. He also produced a

further complex improvisation during Followup.

In the absence of any indices of generalization of improvisation across tool classes, training was later instituted in the second baseline (Hammers). Again, both subjects produced more new improvisations over the Training phase than in Baseline. Luther managed one (simple) improvisation in Baseline and five (one complex) in Training, plus two more complex improvisations in the Followup phase. Ronnie devised six new simple improvisations in Baseline and went on to produce seven new improvisations, all complex, in Training.

With no evidence of across-tool-class generalization apparent in the third baseline (Shoelaces), Training commenced. The effect was more evident in Luther's data. Whereas he had

Fig. 3. Cumulative new tools improvised in the Baseline, Training, and Followup probes by Luther (upper) and Ronnie (lower). These two subjects were paired in a between-subjects multiple-baseline design.

LUTHER
CONTAINERS

RONNIE

made but one (complex) improvisation in Baseline, he subsequently (and fairly soon) produced three (all simple) in the Training condition. Ronnie devised only two new, simple Shoelaces over Baseline, and made two more improvisations (both complex) in Training.

Between-Subject Data

Luther and Ronnie (see Figure 3) were paired in a between-subjects multiple-baseline design across all three tool classes. The training procedure was first introduced sequentially into their respective Container baselines, then into their Hammer, and, finally, into their Shoelace baselines. The data indicate that, for each pair of individual tool classes, increased discovery of new improvisations, especially those of the complex type, was general only following the sequential introduction of the Training procedure.

Figure 4 shows the effect of the sequential introduction of the training procedure for all five subjects on the Hammer component. These results were reported in detail earlier when individual within-subject data were outlined. They are presented here in this form to show their relationship to one another in the between-subjects multiple-baseline design. The data indicate that four of the five subjects improvised little in Baseline, and that a fifth (Ronnie) devised six new hammer substitutes, all designated simple in form. Increased production of new improvisations, especially of complex forms, was generally most evident only after each subject had individually been exposed to the training procedure.

A summary of the data relating to new improvisations, abstracted from the preceding graphs, is provided in Table 3.

These data show that more new improvisations, especially new complex improvisations, were made during Training probes than in Baseline probes. Overall, only 10% of the 29

new improvisations made in Baseline were designated complex, while complex new generalized improvisations accounted for 56% of the 54 new improvisations produced in Training probes. Complex forms also dominated the new improvisations produced in Followup probes.

DISCUSSION

The results from the Baseline probes of four of the five subjects revealed few new improvisations. The exception was Ronnie, who produced a diversity of simple improvisations in the Baseline probes of the Hammers and Containers tool classes. However, comparison between the Baseline and Training phases within each tool class showed that the greatest increases in the diversity of improvisations occurred after specific training was initiated. Thus, generalized improvisation was a function of exposure only to the training exemplars within the same tool class. Additional support for the existence of a functional relationship between the programming of training sessions and generalized improvisation is suggested in the order of appearance of simple and complex improvisations in the Training-phase probe data. In the initial training sessions of each tool class, the exemplar tools demonstrated simple forms of improvisation. Demonstrations of complex forms were introduced later. The probes reflect this scheduling, in that most improvisations made in early training probes were of the simple form, and 33 (89%) of the 37 complex improvisations made over the study were produced during or after exposure to the associated training-exemplar tools.

The effect of the training procedure was most clearly evident in the production of complex improvisations. Probes revealed that these were comparatively rare during Baseline trials. Of 29 new improvisations produced over the 15 Baseline conditions (five subjects $\times$ three

Fig. 4. Improvisation of Hammers in Baseline, Training, and Followup probes by all five subjects.

HAMMERS

Table 3
Summary of New Improvisations

<i>Phase</i>	<i>Type of Improvisation</i>	<i>Hammers</i>	<i>Containers</i>	<i>Shoelaces</i>	<i>Overall</i>
Baseline	# new simple improvisations	9	11	6	26
	# new complex improvisations	1	1	1	3
	% new complex improvisations	10%	8%	17%	10%
	Total # new improvisations	10	12	7	29
Training	# new simple improvisations	17	3	4	24
	# new complex improvisations	15	13	2	30
	% new complex improvisations	47%	81%	33%	56%
	Total # new improvisations	32	16	6	54
Followup	# new simple improvisations	2	0	0	2
	# new complex improvisations	2	1	1	4
	% new complex improvisations	50%	100%	100%	67%
	Total # new improvisations	4	1	1	6

tool classes), only three (10%) were complex. Each of these was devised by a different subject (Elsie, Jimmy, Luther), and fell into different tool classes (Containers, Hammers, and Shoelaces, respectively). In contrast, data from generalization probe trials across the 11 sets of Training conditions (two subjects $\times$ three tool classes, two subjects $\times$ two tool classes, one subject $\times$ one tool class) revealed that of 54 new, generalized improvisations, 30 (56%) were complex in nature. It is evident that the training procedure not only had introduced the children to different, less conventional ways of performing the problem tasks, but also to more sophisticated forms of adaptation, the principles of which they then applied to the probe items with considerable success.

An overall assessment of the effect of the training procedures in producing diverse, generalized improvisations within each tool class revealed that training was more effective for the tool class Hammers and Containers than for Shoelaces. This outcome may have been due in part to at least two factors. First, pounding and storing were performed competently by all five subjects from the beginning of the study, but each one had to be taught shoelace threading in the early baseline sessions. This more limited history of using shoelaces may have contributed to the general lack of responsiveness in this tool class. Second, the

serendipitous availability of a greater number of potentially effective, alternative tools in the Hammer probe item pool (estimated total = 24) and Container probe item pool (estimated total = 14) made possible a greater number of diverse improvisations than was the case for Shoelaces (estimated total = 5).

It should be noted that it was not possible to predict from the outset of the study how many different improvisations would be made in each tool class, hence the open-ended recording system. The totals given above are only estimates, determined from the experimenter's attempts to improvise further alternatives at the end of the study, made to give some idea of the total range within each class. As a group, the children improvised a total of 36 novel tools: 18 Hammers (11 complex), 13 Containers (10 complex), and five shoelaces (two complex). Twenty-one (58%) of these 36 novel improvisations were unique to the Training and Followup conditions, and only a few of them were identified by the experimenter before the study began.

The improvisation skills developed in training continued to be displayed over the various Followup phases, including two instances in which the commencement of followup probes was delayed for over three months after training had terminated. Each subject produced at least one novel improvisation during Followup

probes, and four of those six improvisations were classified as complex. This outcome suggests that the training procedure developed relatively durable skills that continued to be displayed after training ceased.

The within-subject multiple-baseline data showed that generalized improvisation was topographically limited (*cf.* the Garcia, Baer and Firestone, 1971 demonstration of topographical limitations of generalized imitation), in that generalization occurred within a tool class only after exposure to training procedures specific to that class. There was no evidence of generalization of improvisation skills from any trained tool class into any as yet untrained baselines. This limitation of generalization reflects the focus of the training procedure. Exemplar tools, instructions, and descriptive feedback and praise emphasized generalization *within* tool classes. Generalization *between* the topographically dissimilar tool classes was not specifically programmed. Holman *et al.* (1977) also reported topographically limited generalization in the absence of specific generalization procedures designed to promote form diversity across dissimilar tasks. As Holman *et al.* noted, such results indicate the need to program generalization if and when it is sought. The importance of meeting this requirement was emphasized by Stokes and Baer (1977), who also identified a variety of procedures by which this might be achieved.

Use of distractor probe items showed interesting patterns. Typically, the children tried those Distractors that looked appropriate or bore some resemblance to conventional tools during early baseline probes. Over extended baselines, Distractor usage tended to decline and, in some instances, stabilize at a low level. When the training procedure was introduced into a baseline, the immediately subsequent probes reflected a brief resurgence of Distractor use, which then subsided, often stabilizing at levels below those typical of the later sessions of the preceding baselines. The initial attempts often involved Distractors that looked

potentially effective. These patterns suggest that during initial exposure to the pool of probe items, either in Baseline or in Training phases, the children sought conventional-looking substitutes to replace the missing tools, basing their selection on appearances rather than on the essential functional qualities of the missing tool. The subsequent lesser Distractor use, evident as training took effect, raises the possibility that the training procedures may have aided in the process of discrimination between potentially effective and essentially useless alternative tools. The distractor items could have played a role in the formation of this discrimination, aiding in the process of identifying the essential qualities of effective alternative tools.

The two generalization training techniques employed in the training procedure deserve comment. By definition, a problem exists only in the absence of an effective solution; once that is found, there is no longer a problem. But remove that particular means of solution and the problem arises anew. Training sufficient exemplars was seen as a procedure for training multiple solutions; thus, the strategy employed was to expose the subjects to a diversity of unconventional, yet effective, alternative tools. It was anticipated that successful task completion, achieved by using a variety of exemplar tools, would facilitate exploration of, and experimentation with, a diversity of apparently unlikely items in the probe item pool. Eight diverse exemplars of simple improvisations were presented first. Usually, their effect was reflected in generalization probes by a diversity of simple improvisations. The procedure adopted in the programming of complex exemplar tools was somewhat *ad hoc*, since it was not possible to predict in advance which improvisations would be produced or how many exemplars would be required to establish the generalized improvisation. However, the essence of the strategy was to expose the subject to relatively similar exemplar tools until generalization was established. Then, if further, more diverse improvisations of that type were

possible, but not yet made, a diversity of exemplars of that type was presented until either the added generalized improvisations were displayed or the supply of exemplars was exhausted. The result was a procedure that attempted to establish a balance between diversity of exemplars and similarity of exemplar characteristics, which Stokes and Baer (1977) suggested may be important to the success of this procedure. The extent to which that balance was achieved is not known. It did appear that a much more extensive collection of exemplars was required than had been gathered at the outset of the study.

The second generalization training procedure was descriptive praise contingent on the production of successful, novel improvisations. The procedure used in this study differed from that employed by Goetz and associates in the form-diversity studies (*e.g.*, Goetz and Baer, 1973). When reinforcing different forms, they praised only the first appearance of a form within any given session, thus adopting a novel-for-that-session criterion of novelty. The criterion of novelty was more stringent in the present study. During training in the various tool classes, new improvisations were praised only once, on the first occasion of their successful use. Their first successful use in subsequent sessions was noted only with descriptive feedback, never praise. Use of this novel-for-this-experiment criterion of novelty was possible in the present study because the diversity of improvisation was facilitated by training with exemplars. Entirely novel forms thus were more likely to be produced, and praised, with greater frequency than would have been the case if the Goetz and Baer training procedure had been used. The major function of the descriptive praise may have been a discriminative one, marking those occasions on which novel and effective generalized improvisations were produced.

The appearance of plateaus in the generalization probe data often was accompanied by repetitive use of a previously developed im-

provisation, despite continued exposure to exemplars demonstrating new alternatives. This effect was most evident in the Hammer data where, once discovered, Item *H* (a mallet made by pushing length of rod into a drilled wooden block) proved a popular, efficient, and frequently used tool. As might be expected, the discovery of an efficient tool naturally made the search for further alternatives less imperative. Furthermore, the more readily available and more frequently delivered natural contingencies provided by successful task completion could have constituted a media trap ("any material, activity, or medium that eventually will maintain appreciable rates of child behavior with it, independent of any extrinsic reinforcement" [Baer *et al.*, 1976, p. 10]). If the natural contingencies generated by the interaction between the child and the experimental equipment were more potent than the praise contingent on the production of more unusual, but not necessarily more effective, diverse and novel improvisations, then a halt in the movement along the generalization gradient (*i.e.*, a plateau) would result.

In general, the results of the present study clearly showed that preschool children could be trained, using explicit generalization programming techniques, to display diverse, novel, and generalized improvisation skills within a number of problem tasks. This outcome indicates that behavioral diversity can be trained systematically in activities other than those associated with artistic expression, suggesting the possibility of extending the embryonic functional analysis of creative behaviors (Holman *et al.*, 1977) into the realm of creative problem-solving.

While the training procedures employed in this study were relatively effective, they involved intensive, individual trainer-trainee interactions across a considerable time span. Furthermore, the generality of the resultant problem-solving skills was limited. Training preschool children to display generalized, resourceful problem-solving behaviors can be

justified in both personal and social terms. But, before effective classroom curricula can be planned, it will be necessary to devise efficient programs that would establish widely generalized problem-solving skills applicable to a variety of problems in a variety of contexts.

REFERENCE NOTE

¹ Goetz, E. M., Jones, K., and Weamer, K. *The generalization of creativity "training" in easel painting to blockbuilding*. Paper presented at the meeting of the Americal Psychological Association, Montreal, September, 1973.

REFERENCES

- Baer, D. M., Rowbury, T. G., and Goetz, E. M. Behavioral traps in the preschool: A proposal for research. In A. Pick (Ed), *The Minnesota Symposia on Child Psychology*, Vol. 11. Minneapolis: University of Minnesota Press, 1976. Pp. 3-27.
- Ballard, K. D. and Glynn, E. L. Behavioral self-management in story writing with elementary school children. *Journal of Applied Behavior Analysis*, 1975, 8, 387-398.
- Bijou, S. W. *Child development: The basic stage of early childhood*. Englewood Cliffs, New Jersey: Prentice-Hall, 1976.
- Brigham, T. A., Graubard, P. S., and Stans, A. Analysis of the effects of sequential reinforcement contingencies on aspects of composition. *Journal of Applied Behavior Analysis*, 1972, 5, 421-429.
- Cole, H. P. and Parsons, D. E. The Williams Total Creativity Program. *Journal of Creative Behavior*, 1974, 8, 187-207.
- Crary, R. W. *Humanizing the school: Curriculum development and theory*. New York: Knopf, 1969.
- Davis, G. A. *Psychology of problem solving: Theory and practice*. New York: Basic Books, 1973.
- Garcia, E., Baer, D. M., and Firestone, I. The development of generalized imitation within topographically limited boundaries. *Journal of Applied Behavior Analysis*, 1971, 4, 101-102.
- Glover, J. and Gary, A. L. Procedures to increase some aspects of creativity. *Journal of Applied Behavior Analysis*, 1976, 9, 79-84.
- Goetz, E. M. and Baer, D. M. Descriptive social reinforcement of "creative" blockbuilding by young children. In E. A. Ramp and B. L. Hopkins (Eds), *A new direction for education: Behavior analysis*. Lawrence: University of Kansas Press, 1971. Pp. 72-79.
- Goetz, E. M. and Baer, D. M. Social control of form diversity and the emergence of new forms in children's blockbuilding. *Journal of Applied Behavior Analysis*, 1973, 6, 209-217.
- Goetz, E. M. and Salmonson, M. M. The effect of general and descriptive reinforcement on "creativity" in easel painting. In G. Semb (Ed), *Behavior analysis in education—1972*. Lawrence: University of Kansas Press, 1972. Pp. 53-61.
- Gordon, W. J. J. *Synectics*. New York: Harper, 1961.
- Holman, J., Goetz, E. M., and Baer, D. M. The training of creativity as an operant and an examination of its generalization characteristics. In B. C. Etzel, J. M. Le Blanc, and D. M. Baer (Eds), *New developments in behavioral research: theory, methods, and applications. In honor of Sidney W. Bijou*. Hillsdale, New Jersey: Lawrence Erlbaum Associates, 1977. Pp. 441-471.
- Maloney, K. B. and Hopkins, B. L. The modification of sentence structure and its relationship to subjective judgements of creativity in writing. *Journal of Applied Behavior Analysis*, 1973, 6, 425-433.
- Parnes, S. J. Aha! In I. A. Taylor and J. W. Getzels (Eds), *Perspectives in creativity*. Chicago: Aldine, 1975. Pp. 224-248.
- Skinner, B. F. *Science and human behavior*. New York: Macmillan, 1953.
- Skinner, B. F. *Contingencies of reinforcement: a theoretical analysis*. New York: Appleton-Century-Crofts, 1969.
- Stokes, T. F. and Baer, D. M. An implicit technology of generalization. *Journal of Applied Behavior Analysis*, 1977, 10, 349-367.
- Torrance, E. P. Can we teach children to think creatively? *Journal of Creative Behavior*, 1972, 6, 114-143.
- Torrance, E. P. Creativity research in education: Still alive. In I. A. Taylor and J. W. Getzels (Eds), *Perspective in creativity*. Chicago: Aldine, 1975. Pp. 278-296.

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