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REINFORCEMENT AND GENERALIZATION OF PRODUCTIVE PLURAL ALLOMORPHS IN TWO RETARDED CHILDREN[1]

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Morphological dictates of English usage call for the unvoiced allomorph /-s/ to form the plural of singular nouns with unvoiced endings (*e.g.*, cups). Conversely, the voiced allomorph /-z/ is required to form the plural of nouns with voiced endings (*e.g.*, tree). The study sought to determine the extent to which differential reinforcement could control the acquisition of plural allomorphs in two retarded subjects. In Condition 1, one subject was trained with reinforcement procedures on a list of words calling for the /-s/ allomorph. She was then given unreinforced probe items to determine the extent of generalization to words calling for the /-z/ allomorph. In Condition 2, the procedures were reversed and this subject was trained on a /-z/ list and probed for generalization of /-z/ to words calling for /-s/. A second subject was exposed to the same conditions in the opposite order. The results for the two subjects lent unequivocal support for the hypothesis of generalized training effects. It was concluded that appropriate usage of the linguistic response class "plurals" is susceptible to generalized training effects of differential reinforcement.

Guess, Sailor, Rutherford, and Baer (1968) used operant conditioning procedures to establish a generative use of the plural morpheme in the speech of a previously mute, severely retarded girl. After verbal imitation was established as a learned response class, before the onset of the experiment, reinforcement was presented contingent upon correct imitation of singular and plural verbalizations by the experimenter in response to objects presented to the subject singly and in pairs. A generative productive plural usage resulted, the subject correctly labelling new objects in the plural without further initial direct training on each newly presented pair of items. After singular/plural usage was established, the procedures were reversed (reinforcement of plural responses to single objects and *vice-versa*). This produced a corresponding reversal of response by the child. The original usage was then recovered by returning to the previous procedure. In addition, it was found that plural usage extended to trios of objects, as well as to pairs, and that words which in English follow a different rule than the subject's training nevertheless were pluralized according to the rule involved in her training (*i.e.*, "man"-"mans").

A second part of the Guess, *et al.*, (1968) study constituted a separate analysis of the subject's error responses in the course of learning the plural response class. The findings of this sub-experiment provided a general basis for the present study. The error analysis suggested that the subject had more difficulty (in terms of correct response) on those words with terminal vowel endings. A tentative explanation was afforded, based on consideration of the several productive allomorphs of the plural morpheme: /-s/, /-z/, and /-əz/. It was suggested that, in the course of the training conditions, the subject had learned to articulate only the /-s/ allomorph in the production of plural words. Indeed, four of the first five words trained in the initial condition of the study required an /-s/ ending. This possibility was further substantiated by tape recordings

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made during the experiment that indicated that the subject was, in fact, pausing and accentuating the /-s/ allomorph for those vowel ending words that normally require the /-z/ ending. In normal speech, pluralization of those words ending in unvoiced consonant sounds (*e.g.*, cup) requires the unvoiced sibilant ending /-s/, while pluralization of those words ending in voiced consonants (*e.g.*, car) or vowels (*e.g.*, tree) requires the voiced sibilant /-z/. Words ending with the plural consonants themselves, or that end with x, š, ž, č, or ǯ (box, Orange) require /-əz/.

In theorizing on this issue, it was suggested by Cofer (1963) that those words requiring the /-s/ ending encourage the expression of this sound because the final position of the speech mechanisms in producing the word permits continuity of air flow in the plural formation. The same holds true for continuity in the case of voiced plural endings.

Staats (1968) on the other hand, suggested an hypothesis based on a pure stimulus control-reinforcement position. According to Staats, a child in the process of acquiring the plural morpheme is differentially reinforced by the environment over many trials in the presence of plural stimuli for emissions of the correct plural response. After a sufficient number of trials, a discriminated response class (rule) will generalize to novel stimuli, and the child will use plurals correctly.

The present study examined the second hypothesis in an attempt to determine the extent to which differential reinforcement from an adult model can control the acquisition of appropriate or inappropriate plural allomorphs.

METHOD

Subjects

It was crucial to this study that the subjects begin the experiment with a modest verbal usage. They had to be capable of recognizing and verbally labelling objects when presented to them in the singular; but not to be capable of supplying any form of the plural morpheme when presented with the same object in pairs. In addition, the subjects had to be able to articulate the /-s/ and /-z/ sounds necessary to formulate plural words. In accordance with these requirements, a subject selection device was employed as a screening procedure for the experiment.

The initial step of the device tested the subjects ability to produce the component allophonic sounds. They were shown 14 pictures of various objects depicting words with the /-s/ and /-z/ sounds in the initial, medial and final positions. Subjects were selected on the basis of their articulation ability on these components as well as on their demonstrated absence of plurals.

The second step of the screening procedure demonstrated functionally that the subject did not form plurals in his speech. He was shown a series of 11 single objects followed by multiples of the same objects. The child's response to the question "What do you see?", in each instance, displayed his ability to form plurals. Test objects that were not recognized in the singular form were taught to the child in the singular and then presented in a paired (or otherwise multiple) form. Objects calling for irregular plural endings were included in the list. Any plural response to a presentation of multiple objects automatically disqualified the child as a candidate for the experiment.

*S*1, the first subject selected for the study, was a 15-yr-old girl, diagnosed as severely retarded (Binet I.Q. 36). The second subject, *S*2, was an 8-yr-old girl diagnosed as moderately retarded (Binet I.Q. of 51).

Procedure

Both subjects began the experimental procedure with reinforcement training to establish the plural response class. The two subjects were run successively rather than concurrently, and participated in the experiment in sessions that lasted 30 min each and occured twice daily, once in the morning and once in the afternoon.

Subjects sat at a table opposite the experimenter in a sound-proof room, connected by a one-way mirror and intercom system to an adjoining observation room. Various reinforcers and objects used in the study were placed behind a partition near the experimenter but out of the subjects' sight.

Stimuli for the study consisted of various small objects held up in front of the subject either one at a time or as a pair of the same objects. The order of object(s) presentation followed a three-stage sequence, with the number of objects per session determined solely by the 30-min requirement.

In the first stage, the subject was shown a single object and asked: "What do you see?". If the object was correctly named in its singular form within 5 sec of its presentation, a reinforcer was delivered (a bite of ice cream for *S*1, and a sip of Kool-Aid for *S*2). If the subject failed to name the object or named it incorrectly, the experimenter named the object, withdrew it for 15 sec, then re-presented it with the question: "What do you see?". Subjects seldom required more than one correction. Criterion was reached when the subject gave three consecutive correct responses.

In the next stage, subjects were presented with two of the same objects and asked "What do you see?". Reinforcement was contingent on an appropriate plural response. If the subject gave a singular response, or failed to give any response, the experimenter said "No", stated the correct plural label, withdrew the objects for 15 sec and then re-presented them. Again, criterion performance level was three consecutive correct responses.

In the third stage, a random sequence of single and paired objects was presented to the subject. Criterion performance for this stage was reached when the subject gave three correct singular responses intermixed with three correct plural responses, without intervening errors. This training procedure is identical to that described in an earlier study (Guess *et al.*, 1968).

A VR 3 reinforcement schedule was established during the second and third stages of object training about midway through both conditions, with both subjects, to enable insertion of unreinforced "probe" objects within each condition. Each subject received two experimental conditions. Conditions were defined by type of plural noun ending to which the subject was exposed on the training list.

In Condition 1, *S*1 received initial training on a list of objects whose singular forms have voiced endings, thus calling for the voiced /-z/ plural allomorph according to the rule of English morphology. Criterion was reached when the subject had supplied the correct /-z/ plural ending on at least 10 consecutive objects. This was determined by the "plural shift", a correct plural response to the first pair of objects (second stage of training). After the criterion of at least 10 plural shifts, a series of probe objects was intermixed with the training list objects. In order to insure that the subject knew the names of the probe objects, they were trained in the same manner as training list objects in the first stage. It is important to note that multiples of probe objects (second stage) were simply presented for 5 sec and withdrawn with no reinforcement or training given, regardless of the response or lack of response to the pair of items.

Probe objects for the first condition for *S*1 consisted of objects whose singular form ending was unvoiced, thus calling in English morphology for the unvoiced plural allomorph /-s/. According to the differential reinforcement hypothesis, the probe words, though calling morphologically for an /-s/ ending, should show the phonological effects of generalized training on /-z/, and should evoke incorrect /-z/ plural endings. Probe objects were presented in the same manner as the training list objects in the second stage. Probe objects were presented on alternate trials after criterion had been reached and consisted of three replicates of 12 probes for a total of 36.

In Condition 2, the training and probe lists were interchanged. Thus, *S*1 was trained on a list of objects calling for /-s/ plurals and probed with objects calling for /-z/ plurals. Otherwise, the procedure was exactly the same as for Condition 1. Table 1 presents the list of training and probe objects in the order they were presented in Conditions 1 and 2.

The procedure for *S*2 was exactly the same as for *S*1 except that *S*2 was trained on /-s/ ending words in Condition 1 and /-z/ ending words in Condition 2 to counter-balance for possible effects of initial training list. Table 2 presents the list of training and probe objects in the order presented to *S*2 in Conditions 1 and 2.

RESULTS AND DISCUSSION

Reliability

Evaluation of the dependent variable was conducted by having sound tapes of the probe words for each condition, for each subject, rated by two speech pathologists for the audible presence of either /-s/ or /-z/ productive allomorphs.[2] These raters performed their ratings independently and conditions, as well as words within conditions, were scrambled and presented to the raters in random fashion. The raters had no familiarity with the hy-

Table 1

Lists of Training and Probe Objects Presented in Order to *S*1 in Conditions 1 and 2.

Condition 1							*Condition 2*					
1. pen	23. bag	PROBE	2. belt	44. doll			1. cup	18. cat	PROBE	5. car	31. chief	
2. card	24. pig		44. doll				2. hat	19. map		31. chief		
3. key	25. chair	PROBE	3. dart	45. straw			3. book	20. sock	PROBE	6. ball	32. mint	
4. button	26. comb		45. straw				4. boat	21. boot		32. mint		
5. spoon	27. horn	PROBE	4. top	46. ball			5. block	22. tape	PROBE	7. horn	33. soap	
6. gun	28. deer		46. ball				6. fork	23. clip		33. soap		
7. bell	29. pole	PROBE	5. loop	47. car			7. stick	24. chip	PROBE	8. deer	34. chalk	
8. balloon	30. jar		47. car				8. truck	25. cap		34. chalk		
9. ring	31. penny	PROBE	6. tank	48. pen			9. pipe	26. duck	PROBE	9. comb	35. but	
10. shoe	32. dollar		48. pen				10. plate	PROBE 1. tree		35. but		
11. lid	33. record	PROBE	7. tip	49. card			11. tack	27. book	PROBE	10. bear	36. tip	
12. cow	34. camel		49. card				12. sack	PROBE 2. bow		36. tip		
13. bug	35. pencil	PROBE	8. but	50. key			13. nut	28. loop	PROBE	11. record	37. jet	
14. nail	36. spider		50. key				14. goat	PROBE 3. flag		37. jet		
15. dime	37. lion	PROBE	9. chalk	51. button			15. rock	29. pot	PROBE	12. penny		
16. screw	38. spool		51. button				16. bolt	PROBE 4. can				
17. dog	39. bottle	PROBE	10. soap	52. spoon			17. jack	30. rabbit				
18. plane	40. butterfly		52. spoon									
19. cigar	41. bear	PROBE	11. mint	53. gun								
20. bead	42. train		53. gun									
21. peg	PROBE 1. light	PROBE	12. chief									
	43. ribbon											

Table 2

Lists of Training and Probe Objects Presented in Order to *S*2 in Conditions 1 and 2.

Condition 1							*Condition 2*					
1. cup	27. rabbit		53. tack				1. pen	16. screw		27. deer		
2. hat	28. mint		54. nut				2. card	17. dog	PROBE	5. hoop		
3. block	29. chief	PROBE	1. ball				3. key	18. plane		28. jar		
4. stick	30. soap		55. goat				4. button	19. bead	PROBE	6. tank		
5. truck	31. chalk	PROBE	2. car				5. spoon	20. cigar		29. pole		
6. pipe	32. tip		56. bolt				6. gun	21. peg	PROBE	7. hat		
7. plate	33. but	PROBE	3. can				7. bell	22. tee		30. penny		
8. fork	34. tap		57. rock				8. balloon	23. horn	PROBE	8. cup		
9. sack	35. tank	PROBE	4. flag				9. ring	PROBE 1. light		31. dollar		
10. nut	36. dart		58. jack				10. pill	24. chair	PROBE	9. book		
11. tack	37. book	PROBE	5. bow				11. lid	PROBE 2. belt		32. record		
12. goat	38. belt		59. cat				12. cow	25. bag	PROBE	10. boot		
13. bolt	39. stick	PROBE	6. tree				13. bug	PROBE 3. dart		33. camel		
14. rock	40. hoop		60. map				14. nail	26. comb	PROBE	11. block		
15. jack	41. brick	PROBE	7. pen				15. dime	PROBE 4. tap		34. pencil		
16. cat	42. book		61. sack						PROBE	12. boat		
17. sack	43. hat	PROBE	8. card									
18. boot	44. boat		62. boot									
19. tape	45. cup	PROBE	9. key									
20. clip	46. block		63. tape									
21. chip	47. fork	PROBE	10. man									
22. cap	48. stick		64. clip									
23. duck	49. fork	PROBE	11. spoon									
24. book	50. pipe		65. chip									
25. loop	51. plate	PROBE	12. gun									
26. pot	52. sack											

pothesis of the experiment or with the procedures. Only those words on which the raters were in agreement about the allomorphic endings were used in evaluating the hypothesis.

Both subjects were presented with 12 probe words with three presentations of each pair of objects for a total of 36 probes in each condition. For *S*1, the raters were in agreement on the category scored for all 72 probe objects, thus giving 100% reliability for this subject. For *S*2, the raters disagreed on the categorization of two of the 36 objects of Condition 1, but disagreed on none of the probe objects of Condition 2, giving an overall reliability of 98% for this subject.

Condition 1

In this condition, *S*1 was trained on /-z/ ending words and probed for inappropriate generalization to /-s/ ending words. *S*1 made a plural response to 25 of the 36 probes, all of which were rated as having the /-z/ allomorphic ending, although this ending is clearly inappropriate in English morphology. Thus, generalization from the training list of /-z/ allomorph words did indeed occur. In this Condition, *S*2 was trained on /-s/ ending words and probed for inappropriate generalization to /-z/ ending words. *S*2 made a total of 32 plural responses to the 34 reliably judged words. All 32 were rated as having the /-s/ allomorphic endings, though inappropriate. Thus, generalization from the training list of /-s/ allomorphic words did occur. Figure 1 shows the rate of acquisition of correct "plural shifts" on the training lists (probe positions indicated) for both subjects in Condition 1.

Condition 2

In this condition, *S*1 was trained on /-s/ ending words and probed for inappropriate generalization to /-z/ ending words. *S*1 made a plural response to all 36 objects and all 36 were rated as having the /-s/ allomorphic ending, thus showing generalization to probes from the training list as before. In this condition, *S*2 was trained on /-z/ ending words and probed for inappropriate generalization to /-s/ ending words. *S*2 made a plural response

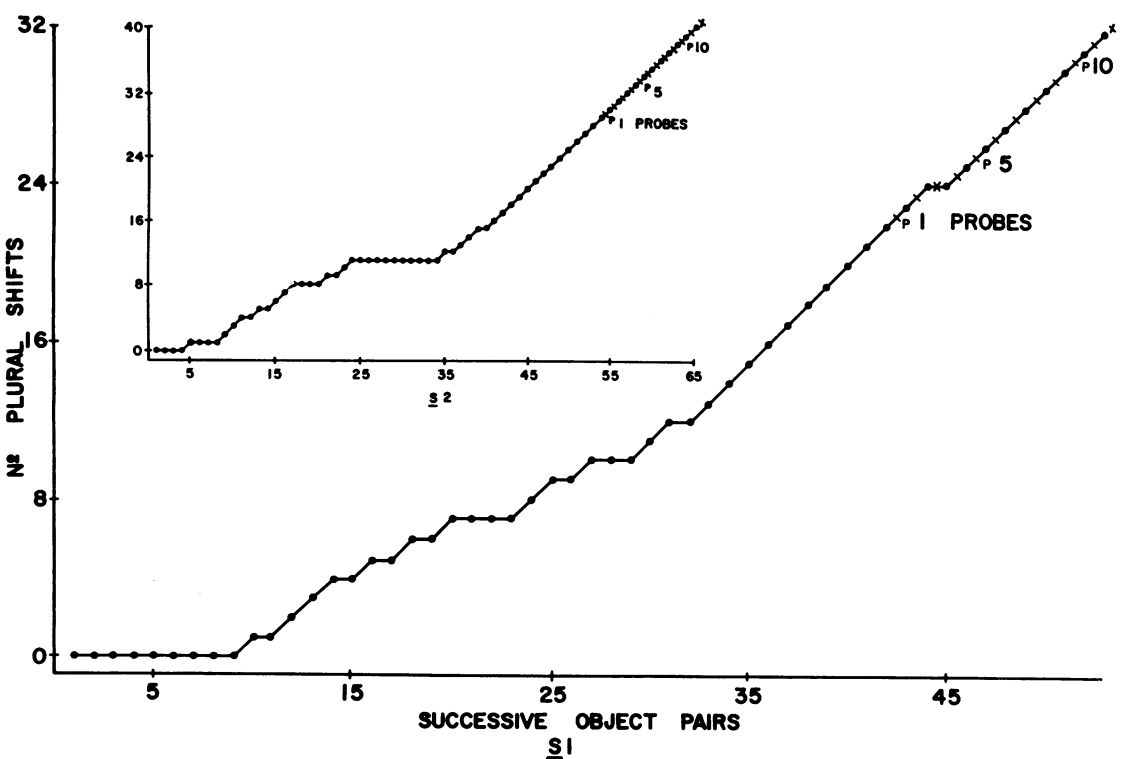

Fig. 1. Cumulative acquisition of plural shifts during Condition 1, with probe positions indicated, is given for *S1* by the larger curve, and for *S*2 by the smaller curve.

to all 36 objects and all 36 were rated as having the /-z/ allomorphic ending, thereby clearly showing generalization to probes from the training list. The rates of acquisition of the plural shifts for the two subjects are similar to the data presented in Figure 1 except that criterion was reached sooner in both cases. *S*1 took 15 trials to criterion in Condition 2 and *S*2 took 18 trials. *S*1's plural shift performance became errorless after the presentation of five object pairs. *S*2 requires eight such trials to become errorless.

A comparison of the two subjects on the effect of initial training list shows a negligible effect on learning allomorphic endings attributable to the allomorph learned first. Summarizing, *S*1 took 42 trials to reach the criterion of 10 consecutive plural shifts in Condition 1 (/-z/ ending words) and 15 trials to criterion in Condition 2 (/-s/ ending words). *S*2 took 50 trials to criterion in Condition 1 (/-s/ ending words), and 18 trials to criterion in Condition 2 (/-z/ ending words).

Some additional data lend further strength to the generalization hypothesis. Many of those words that made up the probes for Condition 2 for both subjects were from the same list of stimulus objects that had been presented to them as training objects in Condition 1. Thus, using *S*1 as an example, the subject was reinforced during Condition 1 for emitting the /-z/ allomorphic ending to CAR, BALL, HORN, DEER, *etc.* She next experienced these same objects as probes in Condition 2 with only the training list for /-s/ interposed between the exposures. On the latter occasion, she was rated as emitting the /-s/ allomorph to these stimulus objects. Thus, the effects of immediate plural training override the effects of previous training in producing a stable and reliable generalized response class.

Data from both subjects lent clear support to the expectation that productive allomorphs of the plural morphological class can be taught, using reinforcement procedures, to a retarded child such that he will generalize from a specific allomorphic response class to the entire morphological class regardless of appropriateness to the dictates of English common usage. The finding lends support to the general notion that "rules" of grammar may be acquired through differential reinforcement in the presence of verbal models as suggested by Skinner (1957), and Staats (1968).

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