

## THE EFFECT OF COMPUTER-EMITTED SPEECH INFLECTIONS DURING VERBAL-INTERACTIVE RESPONDING

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In an early experiment, Greenspoon (1955) confirmed that adult human verbal behavior may come under the control of subtle differential reinforcement contingencies. Later, Truax (1966) demonstrated that differential reinforcement played a role in therapist-patient interactions during "non-directive" (Rogerian) therapy. In a laboratory context, Catania, Matthews, and Shimoff (1982) found that selectively reinforcing rules in opposition to contingencies resulted in participants performing at rates that minimized acquisition of moment-by-moment monetary reinforcement. Ninness, Shore, and Ninness (1999) suggested that differential reinforcement of rule selections is a powerful procedure during human-computer interactions. In this study, we explored the possibility that similar procedures might be obtained using voice-interactive software. During baseline, 4 subjects made voice selections of items displayed on the screen and were exposed to "chimes" as a form of auditory feedback when making selections. In the first differential reinforcement condition, subjects were asked to make voice selections of these same items and participants received brief, positively inflected, comments from the computer (e.g., "mmm-hmmm," "okay," "yes") when making particular types of verbal selections. Selection of other items resulted in similar comments from the computer; however, these comments were devoid of "positive" inflection. In the final session, contingencies were reversed, and differential response rates regressed toward baseline levels. Results suggest that verbal selections of particular items come under the influence of positively inflected, computer-generated, differential reinforcement procedures.

Differential reinforcement usually refers to the process of selecting specific response classes for reinforcement to the exclusion of others (Malott, Malott, & Trojan, 2000). The target behavior may be verbal or

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motor, and the participant whose behavior is selectively reinforced may or may not be aware of the process as it is taking place. Irrespective of the participant's awareness, differential reinforcement acts to change some dimension of the targeted response class (e.g., rate, duration, latency, location, or topography) as one set of responses is selected for reinforcement and competing behaviors undergo extinction (Catania, 1992).

As an early example, Greenspoon (1955) confirmed that adult human verbal behavior may come under the control of differential reinforcement procedures. College students were asked to say words at random while particular words (plural nouns or all parts of speech except plural nouns) were targeted for differential reinforcement. For the first 25 minutes of each session, reinforcement consisted of the experimenter simply vocalizing "mmm-hmmm" (reinforcement) or "huh-uh" (punishment) after these selected parts of speech. In the second 25 minutes of each session, the experimenter did not respond to any of the participants' vocalizations. At the end of each session, participants were asked to identify the experimental contingencies. Most participants could not do so; those few participants (only 10 of 75) who could discern the purpose of the experimenter's "mmm-hmmm" (or "huh-uh") were eliminated from the experimental analysis. Results from different groups established quite conclusively that differential reinforcement with "mmm-hmmm" elevated the frequency of plural nouns, and conversely, "huh-uh" could be used to selectively diminish the same behavior. Interestingly, although the frequency of the precise class of word elevated dramatically during contingent reinforcement, there was little tendency for participants to repeat the same words over and over. This outcome points to the importance of *operant class* as a functional and highly malleable unit of behavior, particularly when human participants have "no idea" that their verbal behavior is the target of some intervention.

Elusive verbally reinforcing consequences also may be operating in therapeutic contexts. For example, psychologists and counselors who provide subtle ongoing interpersonal feedback to clients (perhaps in the form of "mmm-hmmm" or "uh-huh") during therapy may be shaping clients' verbal behavior. This differential reinforcement procedure may be at work even when the therapist has no explicit intention of responding differentially to the client's commentary. Truax (1966) examined the possibility that such subtle shaping procedures might play a role in the therapist-patient interactions during what has come to be known as "non-directive" (Rogerian) therapy. Using tape recordings from a successful case conducted by Carl Rogers, Truax confirmed that during psychotherapy, Rogers tended to respond differentially (favorably) to client comments that were suggestive of the client's growing "insight," improved style of expression, and improved personal judgments (discriminations). Recordings revealed that following the client's high expression of "feelings," the therapist was more likely to demonstrate therapeutic "warmth," "empathy," and utter low-level intonations such as, "mmm-hmmm." Accordingly, increased rate and duration of the client's

self-expressive statements resulted. This outcome falls within the general theory predicted by differential reinforcement. That is, to the extent that any form of therapy includes differential reinforcement of particular classes of verbal behavior, one would anticipate that such verbalizations should become more elaborate and occur at a higher rate. This type of control may be even more likely to occur when it is not an "identified" part of the psychotherapeutic process. In this case, neither the client nor the therapist is aware of the interpersonal dynamic.

Catania et al. (1982) pitted verbal interpretations of cause and effect (rules) against the actual programmed contingencies by having participants press buttons and respond to questions in writing regarding the most efficient way to earn points (money) while performing. When participants were differentially reinforced for producing written guesses that ran contrary to the scheduled consequences, many of the participants' response rates came under the apparent control of the verbal shaping procedure. For example, in one condition, participants could earn more points by pressing the button rapidly than by pressing it slowly because the response was reinforced on a random-ratio (RR) schedule. However, when the participants received reinforcement for incorrect guesses (e.g., "The way to earn more points is to press the button slowly"), they followed the incorrect rule (i.e., they pressed the button slowly even though pressing fast actually produced more points). Differentially reinforcing verbal behavior in opposition to contingencies resulted in subjects performing at rates that decreased their opportunity to maximize monetary gain during the experiment.

In a somewhat similar vein, Wells and Bradfield (1998) describe how eye witnesses often succumb to an inflated false confidence in their inaccurate identification of suspects when differentially reinforced by authority figures. Interestingly, these witnesses asserted that social reinforcement was irrelevant to the determination of the guilt of innocent individuals.

More recently, laboratory research by Ninness et al. (1999) has provided additional evidence suggesting that differentially reinforcing participants' rule selections (decisions) is a more powerful procedure than simply giving participants direct instructions regarding the best way to earn the most money while performing math problems on a computer. For one group of participants, selection of performance descriptions were differentially reinforced in opposition to programmed consequences (earning money). A second group of participants was instructed in opposition to contingencies. Participants who had their selections of inaccurate decisions shaped were more than twice as likely to come under the influence of these decisions than participants who were simply given instructions. The results confirmed the effects of shaping written verbal behavior in comparison to displaying written instructions in a computer-interactive environment. Nevertheless, ongoing research on human-computer interaction (e.g., Cerutti, 1994; Hayes, Brownstein, Haas, & Greenway, 1986; Ninness, Ellis, & Ninness, 1999; Ninness & Ninness, 1998; Ninness & Ninness, 1999; Ninness, Ninness, Sherman, &

Schotta, 1998; Ninness, Ozenne, McCuller, Rumph, & Ninness, 2000) has yet to examine this phenomenon with voice-interactive verbal responding, which, in the future, may be one of the primary modes of human-computer interactions.

### Method

#### *Subjects, Setting, and Apparatus*

Two graduate students (1 male and 1 female) from the Department of Human Services at Stephen F. Austin State University and 2 staff members of the Nacogdoches Memorial Hospital (1 male and 1 female) were randomly selected and served as participants. Following informed consent, subjects were seated before a Dell Inspiron 5000e laptop computer (700 MHZ processor and 320 MB RAM) with a 14-inch screen. A standard Labtec desktop microphone was attached to the unit. Voice-interactive software, written by Chris Ninness in Visual Basic 6 and C++ for IBM PC compatible machines, interfaced with Dragon Naturally Speaking 5 and DragonXTools speech recognitions systems to provide voice recognition and auditory verbal feedback to the subjects. The study was conducted in two different university classrooms and two different hospital offices; however, during the experiment, all rooms were empty and subjects were positioned so as to preclude potential distractions and interference from outside sources.

#### *Experimental Design*

Four single subject ABA designs were employed to ascertain the effect of various types of computer-generated verbal feedback on subjects' voice selection rates. During the baseline and reversal conditions, subjects made voice selections from three available computer brands (Alpha, Beta, or Delta) and six supplemental features/computers (printer, scanner, screen, speakers, laptop, or mouse) displayed on the screen. During baseline and reversal, these selections did not result in differential consequences. The computer simply provided a "chime" signaling the program's recognition of a particular verbal selection. However, during the treatment condition, voice selection of specific brands of computers and particular components resulted in randomly generated, positively inflected, brief verbal comments from the computer. Selection of alternatives brands and components resulted in similar forms of verbal feedback; however, these comments were devoid of positive inflection. Minute by minute voice selection rates of various computer brands and related components were continuously recorded on the hard drive. Planned comparisons of Beta selection rates were contrasted across baseline, treatment, and reversal conditions.

*Reliability checks.* Before and after the experiment, computer disk recordings of voice selections per min were calibrated and compared to hand-recorded calculations of voice selections per min. There were no discrepancies. Also, following each 30-min session, one of the

researchers reviewed the computer output of each subject's voice selections/min across baseline, treatment, and reversal conditions. All computer output was independently tallied by a second researcher and scored for reliability. Calculation of agreements was obtained by dividing the number of min-by-min agreements by the number of agreements plus disagreements and multiplying by 100. Reliability coefficients between the two researchers were at 100% for all data sessions.

### *Procedures*

Prior to baseline, subjects were informed (via the researcher) that they could earn a small amount of money (up to \$5.00) for making "efficient voice selections" of various computers and components displayed on the screen before them. No other instructions were provided.

*Baseline.* During a 10-min baseline session, subjects made voice selections from an array of computer items displayed on the screen and received audio feedback. Each selection of a computer brand (Alpha, Beta, or Delta) resulted in a "chime" being emitted from the laptop computer. Concurrently, a 3- x 3-in picture of the computer brand was displayed on the screen. However, all three computer brands and components were of the same structural design, size, color, and configuration. Essentially, these were simply generic examples of screens, speakers, keyboards, and so forth.

*Differential verbal reinforcement.* In the treatment condition, subjects were asked to make voice selections from the same array of items listed on the screen; however, all participants (male and female) received prerecorded female, positively inflected, feedback from the computer (e.g., "mmm-hmmm," "okay," "yes") when verbally selecting a Beta computer or selecting a speaker (Beta) or a laptop (Beta) from the array of screen, printer, scanner, speakers, laptop, and mouse. Note: For experimental purposes, speakers and laptops were arbitrarily coded as Beta selections, screen and printers were coded as Alpha selections, and scanner and mouse were coded as Delta selections. Verbal selections of Alpha and Delta brands or components resulted in the same or very similar comments being emitted from the computer, but these comments were devoid of positive inflection.

*Reversal.* In the final session, differential reinforcement contingencies were reversed to baseline conditions. Again, voice selections of all computer brands and components resulted in chimes rather than verbal feedback. At the conclusion of this reversal session, all subjects were asked to identify the experimental contingencies. Participants provided written responses to the following question, "At any time during the experiment, did you feel that the computer was suggesting (or hinting) that you should select one computer brand or component over another?" Irrespective of written responses or response rates during the experiment, all subjects received \$5.00 for their participation. Subsequently, they were individually debriefed regarding the details and purpose of the study.

## Results

During the baseline phase, none of the subjects displayed a conspicuous preference for any particular type of computer or component. Figure 1 shows

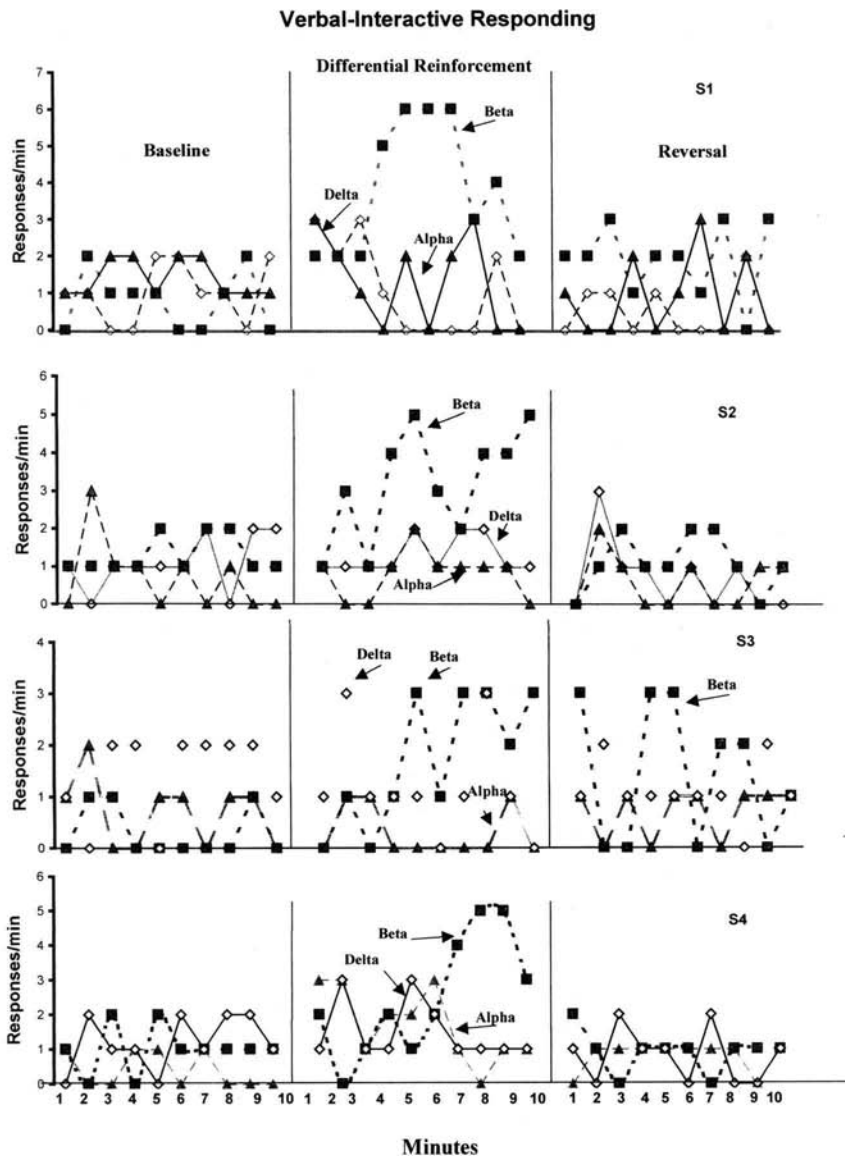


Figure 1. Verbal selections per minute for 4 subjects during baseline, differential reinforcement, and reversal to baseline conditions. During differential reinforcement, subjects received positively inflected verbal feedback from the computer for making voice selections of Beta. Alternative voice selections resulted in the same verbal feedback from the computer that was devoid of positive inflection.



that for all 4 subjects verbal response rates fluctuated erratically between 0 and 3 responses per min on selections of all computers.

With the introduction of differential reinforcement by way of brief positively inflected verbal feedback from the computer, all 4 subjects showed varying degrees of response differentiation. Subject 1's verbal selections of Beta began to elevate over Alpha and Delta during the 4th min of positively inflected verbal feedback from the computer. This subject sustained a relatively high rate for 3 min (six Beta selections/min) and then fell back to baseline levels during the last 3 min of treatment. Subject 2's rate of Beta selections began to increase slightly during the 4th min, rose to a high of five/min, and fluctuated between two and five Beta selections/min throughout the remaining minutes of the treatment session. Subject 3 did not show an increase in Beta selections until the 5th min. For the remaining 5 min of the treatment session, his selections of Beta bounced between three and one responses per min. Interestingly, Subject 3's elevated Beta response rate was preceded by a high rate of Delta selections (three Delta selections/min) during the 2nd min of the session. His selections of Delta fell for several minutes but reemerged during the 8th min of the treatment session. Subject 4 did not show any sensitivity to the differential reinforcement procedure until the 7th min of treatment. At that time, his rate of Beta selections rose to four and five selections/min and dropped to three/min during the last min of the session. Concurrently, Subject 4 showed slight increases in his rate of selecting Alpha and Delta at various times throughout the session; however, his responding is well differentiated throughout the duration of the final 4 min of the treatment session. During the reversal condition, 3 of the 4 subjects showed some degree of regression to baseline levels of performance rates and response differentiation. Subject 3 emitted very high rates of Beta selections during 3 min of the reversal condition.

Data were summarized by contrasting the subjects' voice selections of Beta computers and components across baseline, treatment, and reversal conditions. Randomized repeated-measures analysis of variance (Edgington, 1995) computed on [www.lcsdgc.com/psychStats](http://www.lcsdgc.com/psychStats) yielded significant increases in the planned comparisons of the average selection rates of Beta computers and Beta components during the differential reinforcement condition ( $p = 0.037$ ).

Following the experimental sessions, subjects responded to interrogatives. Of the 4 subjects, 3 wrote comments to the effect that they *did not* feel that the computer had been suggesting (or hinting) that they should pick one computer brand or component over another; however, Subject 3 wrote that selecting "scanners or speakers" resulted in the computer providing a more "affirmative reply" to his selection. His interpretation of the experimental contingencies was partially correct. Selecting "speakers" did result in positively inflected verbal comments from the computer; however, selecting "scanners" did not.

## Discussion

Greenspoon (1955) confirmed that adult human verbal behavior may come under the control of subtle verbal differential reinforcement procedures. In his classic experiment, college students were asked to say words at random, while particular types of words were targeted for verbal reinforcement. Following the reversal condition, participants were asked to identify the experimental contingencies, and the vast majority of participants could not do so. Greenspoon's results suggest that unbeknownst to most human subjects, subtle forms of brief differential reinforcement may elevate the frequency of selected parts of speech. In a somewhat similar vein, our subjects received differential reinforcement in the form of brief, positively inflected, verbalizations from a laptop computer when they made voice selections of particular computer brands and components. Selection of other items resulted in similar randomly generated comments from the computer; however, these comments were devoid of positive inflection. Consistent with the Greenspoon experiment, our subjects displayed varying degrees of sensitivity to the experimental preparations. And, consistent with Greenspoon's results, most of our subjects could not identify the contingencies. Although Subject 3 correctly noted that the computer's voice inflection changed on some occasions, he was able to accurately describe only one of the three differential reinforcement conditions. Moreover, independent of his partial "awareness" of the experimental contingencies, his behavior came under the influence of differential reinforcement throughout most of the treatment session. Indeed, this subject's ability to partially describe the experimental arrangements in the form of a self-generated rule (cf. Rosenfarb, Newland, Brannon, & Howey, 1992) may have contributed to his sustained high rate of Beta selections during the reversal condition. However, at this stage of our research, we can only conjecture the extent to which verbal rules may have interacted with our treatment and reversal conditions (cf. Ninness, Shore, & Ninness, 1999).

Important to point out is the fact that most of our subjects did not show well differentiated verbal responding until they had been exposed to 4 or 5 minutes of treatment. These latencies may limit the impact of such procedures if they were applied in more traditional formats (e.g., voice web interactions). Nevertheless, more sophisticated experimental preparations than provided by our current software may have potential for generating faster and more dynamic effects.

*Implications.* As a practical matter, it is tempting to speculate the extent to which similar strategies might influence human verbal behavior in other contexts. For example, similar strategies might have implications for a number of disciplines in which humans interact verbally with computers. In the near future, many daily decisions (e.g., home shopping, on-line investing, and responding to various polls and surveys) could be made while vocalizing to and receiving auditory feedback from computers. In the quickly evolving technologies of finance, marketing,



political science, educational psychology, and a host of computer-interactive disciplines, a wide range of dynamics may be at play during oral instructions and specifically designed auditory and video feedback in multimedia control. Sound and animated images can be generated that provide close approximation to natural verbal exchanges between people. Increasingly, a more natural flow of communication and influence could go in both directions. Future research that examines a wider range of computer-simulated social responses (e.g., facial expressions, eye contact, and gestures emitted in conjunction with the computer's auditory feedback) may show enhanced influence on human behavior. If, as hypothesized, such multimedia computer feedback has a subtle influence on humans' interactive responding, a continued experimental analysis of this emerging technology and its effect on human behavior appears warranted.

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