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A SINGLE-SUBJECT APPROACH TO EVALUATING VEHICLE SAFETY BELT REMINDERS: BACK TO BASICS

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A single-subject ABA reversal design was applied to evaluate the effectiveness of a limited 8-s safety belt reminder system and two modified reminder systems (a delayed and second reminder) to increase the safety belt use of 13 drivers. The research was conducted with a specially equipped research vehicle that permitted the manipulation of different safety belt reminder stimuli and the unobtrusive recording of a driver's belt use. For 2 subjects, the limited 8-s reminder increased safety belt use. For another 2 subjects, the second reminder markedly increased belt use. Some subjects were uninfluenced by the reminder systems presented; others always buckled up during both baseline and intervention conditions. The approach and results are discussed with regard to the application of behavior analysis methodologies (e.g., cumulative records) and principles (e.g., schedules of reinforcement) to advance the utility and investigation of safety belt reminder systems.

DESCRIPTORS: transportation safety, stimulus control, safety belt use

For the past two decades, researchers have tried to motivate a seemingly intractable population of drivers and passengers to use vehicle safety belts. During this time, an array of intervention strategies has been mobilized to promote safety belt use (e.g., mass media communications, education programs, legal mandates, engineering technologies, and various behavior change tactics; for comprehensive reviews see Geller, 1990; Streff & Geller, 1986; Thyer & Geller, 1990). One widespread intervention strategy receiving modest empirical study has been the application of electronic safety belt reminder systems in passenger automobiles and trucks sold in the United States.

Since the early 1970s, automobile manufacturers have responded to a federal standard requiring installation of electronic safety belt reminders in all automobiles sold in the U.S. (Federal Safety Standards, 1971). Three different types of safety belt reminders evolved: interlock, unlimited, and limited reminder systems. Interlock reminder systems present visual and auditory stimuli (e.g., an illuminated safety belt icon light and a buzzer or chime signal) and a response contingency (i.e., a vehicle's engine could not be started until the driver-side safety belt was extended 4 in. from its normally stowed position or was fastened to the belt receptacle). Unlimited reminder systems present visual and auditory stimuli that continued until the driver buckled up. Limited reminders present visual and auditory stimuli for a specific time (e.g., 8 s) and then terminate automatically. In contrast to interlock and unlimited reminders, the limited reminder does not require belt use before terminating. However, a driver can avoid or turn off any of the three reminder systems by fastening the driver-side safety belt before the signal begins or elapses.

Early studies found that interlock and unlimited reminder systems, compared to limited and non-equipped vehicles, were associated with the highest levels of safety belt use among drivers (three to seven times above the national average at the time).

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However, the effectiveness of the interlock and unlimited reminder systems was short lived, because most of these systems were disconnected or circumvented (Geller, Casali, & Johnson, 1980; Robertson, 1975a). As a result of negative public reaction to the unlimited and interlock systems, the federal government revised the standard by attenuating the temporal duration and the response contingency presented by these reminder systems (United States Code, 1974). The current standard for safety belt reminders states that drivers not buckled up upon turning the ignition key will receive limited auditory and visual signals for not less than 4 s but not more than 8 s.

Although the public apparently prefers the limited safety belt reminder, research has shown no significant differences between the belt use of drivers in vehicles with the limited reminder and drivers in vehicles with no electronic safety belt reminder (Geller et al., 1980; Robertson & Haddon, 1974; Robertson, 1975a, 1975b). These results suggest that limited reminder systems are ineffective. This conclusion, however, is based on group data collected during the 1970s in studies whose research methods obscured potential relationships and variables operating at the individual level of analysis. Indeed, an analysis of the functional utility of a limited safety belt reminder is needed in the current era of greater societal support for the use of vehicle safety belts.

An individual analysis was employed in the present study to explore effects of a limited 8-s sound–light safety belt reminder system and two modifications of this reminder system on safety belt use. The two modifications altered the scheduling of the limited reminder by changing the presentation time of the visual and auditory reminder stimuli. First, the onset of the limited reminder system was delayed for 5 s after the ignition was activated by the driver; next, a second limited reminder was provided if the first reminder was not followed by belt use.

The delayed limited reminder addressed the possibility that other stimuli and responses frequently associated with engine start-up may compete with or overshadow the safety belt reminder. In other words, when a vehicle's ignition is turned on, a limited reminder is simultaneously activated along with engine noise and other instrument panel lights. We hypothesized that a safety belt reminder would gain salience if its onset were delayed until these other collateral stimuli had terminated. In addition, we studied the effects of presenting a second limited safety belt reminder to an unbuckled driver after the vehicle came to an initial complete stop (e.g., at an intersection). This innovation suggests that the salience of the safety belt reminder was increased and also provided temporal novelty, because the second reminder was not dependent on a fixed time interval (as in the delayed condition) but on the driver's first complete stop (which changed from trip to trip).

METHOD

Subjects and Settings

A total of 13 undergraduate college students (6 females and 7 males, from 19 to 26 years old) participated by driving a research vehicle on a driving course consisting of six trip segments. Subjects were selected according to answers they gave to one question on a 65-item survey addressing fuel conservation, traffic regulations, and issues regarding driving behavior (e.g., speed, radio use, eating habits while driving). Subjects were selected based on their answers to the question: "Over the past month, what average percentage of the time did you use a safety belt while driving?" Subjects selected were those who indicated, through written self-report, that their belt use was between 30% and 70%, thereby suggesting that their safety belt use was variable and thus potentially modifiable. The purpose of the study was disguised from the subjects by explaining that the research involved "an analysis of the fuel efficiency performance of computerized engines in large vehicles." Subjects were compensated one extra-credit point per experimental session, applied toward their final grades in a psychology course. Two selected subjects declined to participate.

Research vehicle. The experiment was conducted in a four-door sedan[1] outfitted with electronic equipment that automatically recorded driver safety belt use and trip duration and permitted the selection of different safety belt reminder stimuli and temporal arrangements. Each trip segment was defined as a driver turning on the ignition, driving for more than 1.5 min, and then turning off the ignition. The electronic recording equipment was stored in a locked control box in the vehicle's trunk.

Driving course. At the start of the first session, subjects reviewed a map that diagrammed a sequence of six trip segments with designated stop locations on the driving course. Subjects were instructed to drive the vehicle to six specific community locations using certain town and highway roads. At each stop location, subjects were directed to pull over, turn off the ignition and conduct the toggle-switch routine (discussed below), thus completing a trip segment of the driving course. Each stop location was familiar to the student population (i.e., university, mall, and grocery-store parking lots). Subjects were informed that a map similar to the one used during initial instruction was located in the vehicle's trunk and could be reviewed during the toggle-switch routine. The entire driving course (i.e., one daily session) took an average of 30 min to complete, with each of the six trip segments ranging from 3 to 9 min.

Toggle switch. A box with a toggle switch and on-off lights on its top was positioned inside the trunk, adjacent to the control box. At each of the six stop locations, subjects were asked to (a) turn off the ignition, (b) exit the vehicle, (c) open the vehicle's trunk, (d) flip the toggle switch adjacent to the control box, (e) review the driving course map, if necessary, (f) close the trunk, and (g) reenter the vehicle, drive to next destination, and repeat Steps (a) through (g). The toggle-switch routine was designed to provide a plausible reason for subjects to turn off the ignition and exit and reenter the vehicle, thus providing an opportunity to buckle up. Consequently, during each experimental session this routine set the occasion for six repetitions of the antecedent conditions and behaviors leading up to the presentation of the safety belt reminder. The toggle-switch routine was explained to subjects as necessary for "transferring fuel-efficiency data to the vehicle's computer memory," implying that their compliance was verifiable. Actual compliance was inferred by reviewing the computer data (i.e., the number and duration of each trip segment).

The safety belt. The safety belt was a standard one-piece lap and shoulder harness with the retractor mechanism mounted next to the bottom rear of the front seat. This permitted relatively easy access to the belt buckle because the belt buckle and retractor mechanism moved together with seat adjustments.

Experimental Conditions

There were four different experimental conditions presented to unbuckled drivers when the ignition key was turned: (a) the ***no-auditory*** condition presented no auditory signal but did present an 8-s visual signal, (b) the ***limited*** reminder condition presented an 8-s auditory and visual signal, (c) the ***delay*** condition presented a limited 8-s reminder after a 5-s interval, and (d) the ***second reminder*** condition presented the first of two possible limited 8-s reminders; if a driver remained unbuckled after the first reminder, he or she was given a second limited 8-s reminder when the vehicle came to its first complete stop. The presentation of any of the above reminder conditions was terminated or avoided when drivers buckled up.

[1] The research vehicle (a 1984 Cadillac Seville) and the electronic equipment were provided, designed, and built by the General Motors Corporation and the Environmental Activities Staff of the General Motors Research Laboratories, Warren, Michigan. The vehicle's reminder light was located on the lower left-hand side of the instrument panel and was slightly obstructed by the steering wheel. The reminder light was deemed a minimal requirement by legal and human subject reviews at both General Motors Corporation and Virgina Tech. The electronic chime was a "melody synthesizing integrated circuit" Model C8301, Rittenhouse Division, Emerson Electronic Co. GM part No. 1624406. The electronic buzzer was a standard piezo buzzer. The decibel ratings of the chime and buzzer were 61 dB and 71 dB, respectively. The chime signal gave six pulses per 8 s, whereas the buzzer was continuous for 8 s. When starting the Cadillac's V8 engine, the relative background noise peaked at 68 dB within the first 2 s and then decreased abruptly to a constant 58 dB.

Two types of sound (i.e., chime and buzzer) were used and were varied across subjects.

Procedure

Each subject drove the research vehicle on 6 or 9 separate days over a 12-week period (one academic quarter). Prior to the first day of driving, subjects were introduced to the driving course and toggle-switch routine. Subjects were told that the driving course was designed to simulate a typical driving episode, such as running errands, going shopping or attending university classes. Driving sessions were postponed during inclement weather. Subjects ended their participation by filling out a questionnaire designed to assess their knowledge of the experiment's purpose. After the experiment was completed, all subjects received a letter from the authors revealing the true purpose of the research. At the time of this research, Virginia did not have a mandatory safety belt use law.

Experimental design. During baseline, subjects were given either a standard limited 8-s reminder or the no-auditory condition. The delayed and second reminder conditions were evaluated using an ABA reversal paradigm, with phase changes and conditions varying as a function of response levels. If a subject's response level showed no increase in safety belt use within a specific condition, a sequential intervention procedure was implemented. In these cases, the following sequence of alternative reminder conditions was presented: limited, delayed, and second reminder. Whenever a subject's belt use increased during a specific condition, a reversal to the baseline condition was performed.

Equipment Reliability

Reliability checks of the safety belt reminder hardware and measurement device were conducted after every fourth experimental session. For these checks, the first author or a research assistant compared reminder hardware settings and data readouts with actual reminder stimuli presented and belt use. Over the course of the experiment, 42 trip segments were checked and the equipment was 100% accurate.

RESULTS

Six of the 13 subjects showed consistently high safety belt use (i.e., 95% or higher) across baseline and all subsequent experimental phases. Therefore, an evaluation of the different reminder systems was preempted for these drivers. Figure 1, for example, depicts Jeff's consistent belt use, which is representative of these subjects' performances. The data are portrayed as a cumulative record. The abscissa is defined as number of driving opportunities, with each abscissa tick representing the beginning of a daily session consisting of the six-segment driving course. Each triangle represents a buckle-up opportunity. The ordinate is defined by the cumulative count of buckle-up responses. Slopes denote the relative frequency of safety belt use for a particular session. After each daily session of six trip segments, the cumulative record reset for the next session.

During baseline, the remaining 7 subjects all demonstrated no or variable use of the safety belt. Of these 7 subjects, 3 displayed no increases in belt use when presented in succession the following reminder conditions: baseline, the 8-s limited, delayed, and second reminders. Also depicted in Figure 1, for contrast, is Sue's consistent nonuse of the safety belt across all conditions, which is representative of these subjects' performances.

Figures 2 and 3 show the remaining 4 subjects' belt use data. As shown in Figure 2, Joe's baseline belt use under the no-auditory reminder condition was 72%. Joe was then given a limited reminder; subsequently, his safety belt use increased to 100%. A return to baseline resulted in an apparent proportional decrease in belt use to 67%. When presented the no-auditory condition, Bruce's baseline belt use was zero. He then received the limited reminder and showed a robust increase in belt use to 100%. During a return to baseline, Bruce's belt use dropped to 8%. When the limited reminder was reinstated, Bruce's belt use again increased to 100%.

Figure 3 depicts the data of 2 subjects who initially received a limited sound–light reminder. For the first two sessions, Tom's belt use during

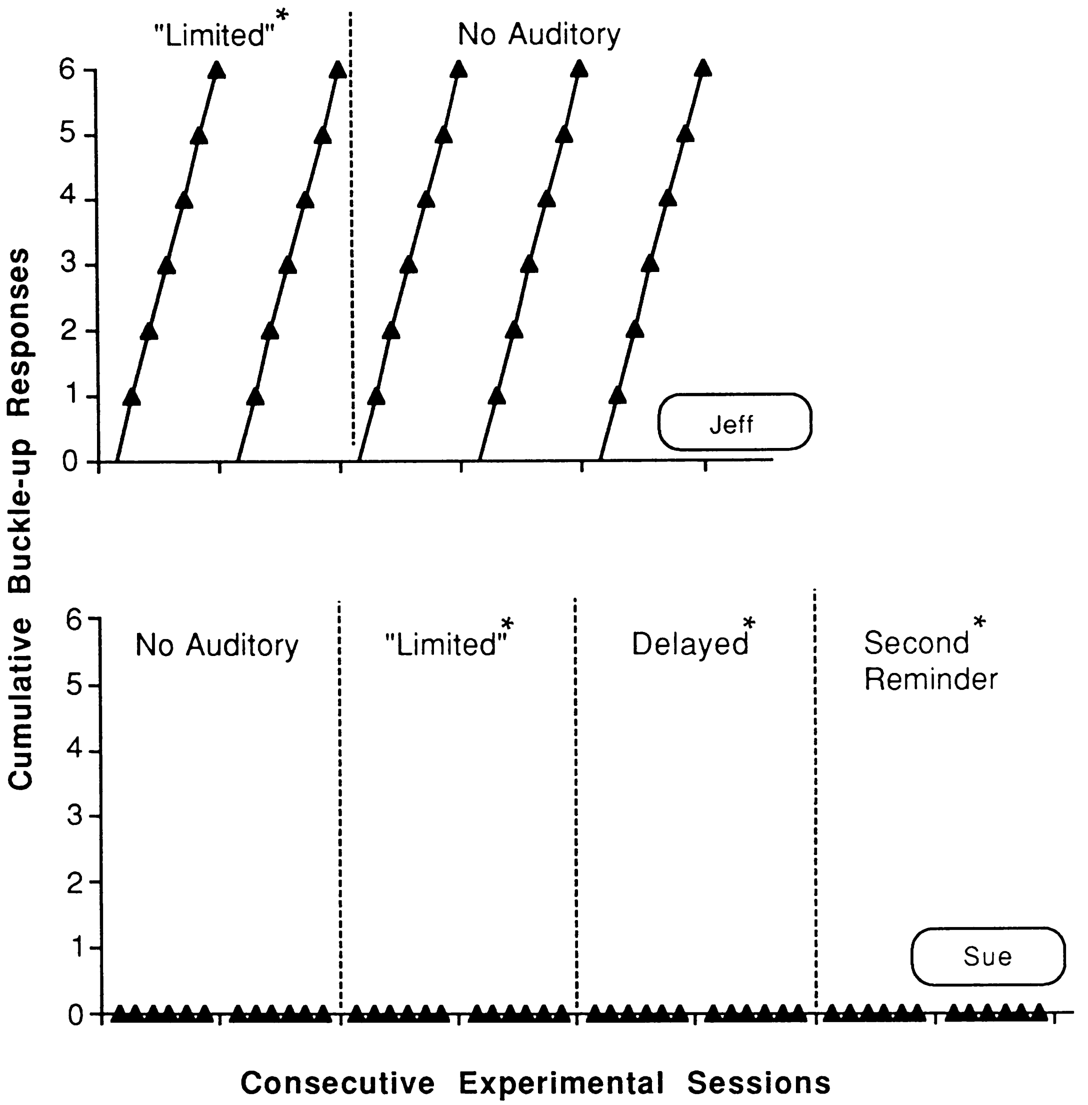

Figure 1. Cumulative records of safety belt use for Jeff and Sue. Jeff represents those subjects (n = 6) who consistently used their safety belts regardless of the reminder conditions, and Sue represents those subjects (n = 3) who rarely or never used their safety belts, despite the different reminder conditions presented. For all figures, an asterisk (*) by the condition label indicates that a chime signal was used; otherwise a buzzer signal was employed.

baseline was consistently high but declined abruptly during the next two sessions for an overall average of 50%. Presentation of a 5-s delayed reminder was associated with little belt use (17%). During the second reminder condition, Tom's belt use increased to 100%. Unfortunately, scheduling problems prevented an attempt to return to baseline. Steve's belt use rate across the limited and delayed reminder conditions was zero. When Steve received the second reminder condition, his belt use increased from 0% to 67%. During the following withdrawal phase, Steve's belt use declined to zero.

Our postexperiment survey indicated that no subject was aware of the actual purpose of the study. Most said the experiment concerned map reading, map memorization, or vehicle speed and braking performance. It is noteworthy that no significant correlation was found between subjects' self-reported and actual safety belt use in the experimental vehicle.

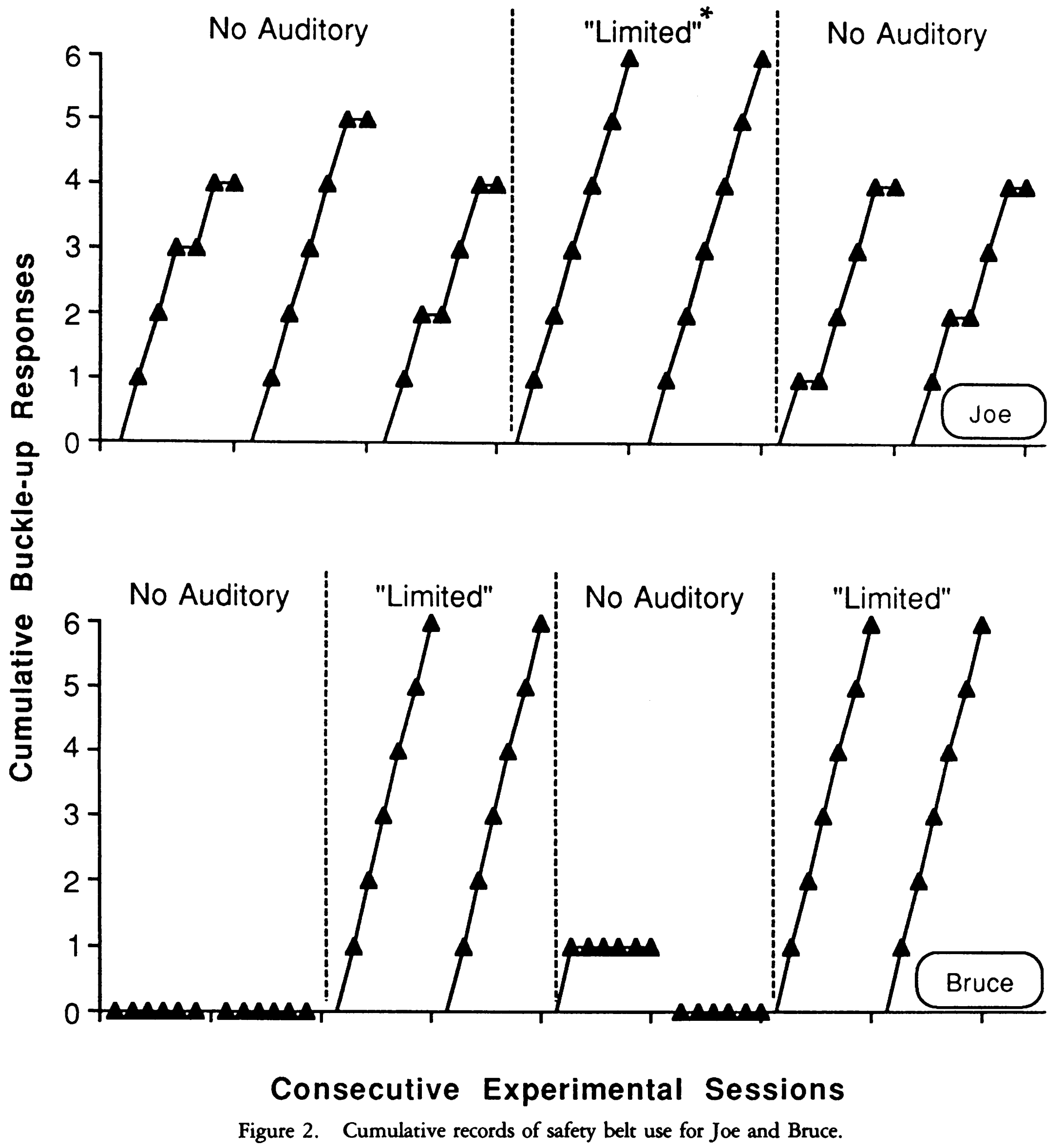

Figure 2. Cumulative records of safety belt use for Joe and Bruce.

DISCUSSION

During baseline, 7 of 13 drivers showed no or variable safety belt use. The intervention results indicated that the safety belt use among 4 of these 7 drivers (57.1%) was markedly influenced by a safety belt reminder. Two of these subjects were influenced by the presence and withdrawal of an 8-s limited reminder. The other 5 subjects, who were not influenced by the limited reminders, were given the delayed reminder and then the second reminder conditions using a sequential intervention procedure. Of the 5 drivers given the 5-s delayed reminder, none showed an increase in safety belt use. However, 2 of these subjects (40%) showed dramatic increases in belt use following exposure to the second reminder condition.

Our results suggest that past reports claiming the limited reminder to be completely ineffective (e.g., Robertson & Haddon, 1974) may be pre-

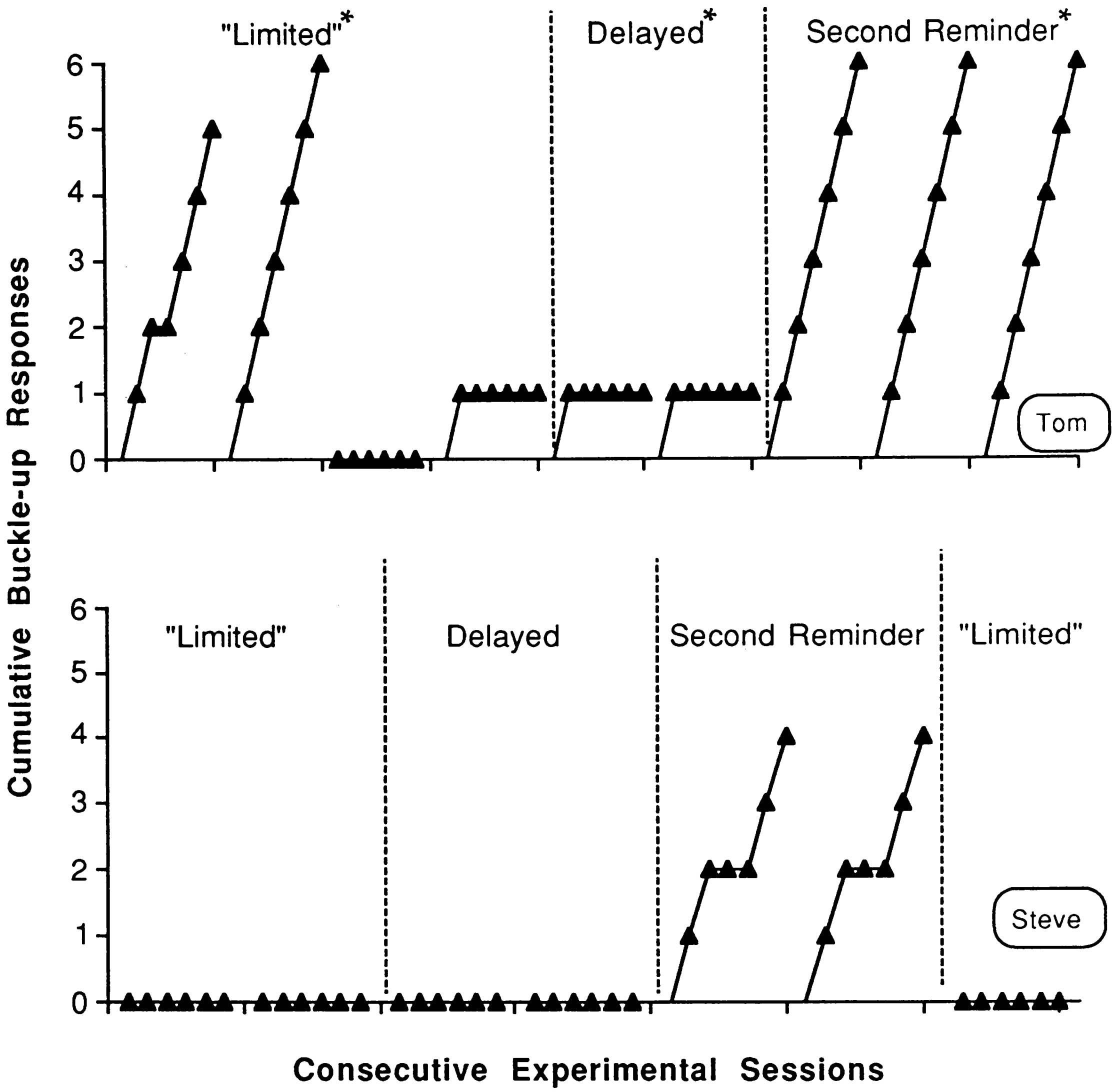

Figure 3. Cumulative records of safety belt use for Tom and Steve.

mature. These earlier results were dependent on group designs and were not designed for a functional analysis. Rather, these studies showed only large-scale associations between belt use and reminder devices (e.g., Geller et al., 1980; Robertson & Haddon, 1974). Unfortunately, these reports have apparently discouraged further research into factors that may contribute to the ineffectiveness of a limited reminder. It also seems that these reports have inhibited study of factors that may promote the functional effectiveness of an electronic safety belt reminder.

In the present research, we introduced a behavior analysis approach to the evaluation of vehicle safety belt reminders. By selecting a small and relatively homogeneous group, we were able to study individual subjects across repeated measures, thus permitting an analysis of variability and a flexible design strategy (i.e., response-guided research, Edgington, 1983; Johnston & Pennypacker, 1980). Response-guided and response-focused research uses raw data counts to examine response variability, stability, and change (as represented in our use of a quasi-cumulative record). However, improvements are called for within our single-subject methodology, including longer baseline and intervention phases and greater diversity in subjects.

The above temporal limitations subsequently prevented a more extensive parametric analysis of the intervention variables studied. Therefore, our findings must be judged as preliminary but encouraging. Although the 5-s delayed reminder showed no effects, future research might analyze a range of different delay intervals. Also, investigators might study the effects of a range of reminder-signal durations. However, our results indicate that further study of a second reminder may be most promising. Research might explore what aspect(s) of the second reminder are critical, including (a) the second presentation of a reminder, independent of when onset occurs; (b) the variable-onset scheduling (as in the case of our study); and (c) an extreme delay of onset, be it fixed or variable; or some combination of the above. These modifications, of course, must be reconciled with the dangers they may pose in distracting drivers engaged in demanding traffic situations.

Another potential limitation involves the difference between actual driving conditions and the contrived experimental conditions presented to our subjects. Although efforts were made to design a driving course similar to routes and destinations that subjects typically drove, the use of the toggle-switch routine and the vehicle itself (i.e., a Cadillac) suggests a need for further research into the generalization of these findings. For example, future research could explore generalization by using a delivery-service scenario (actual or contrived) and a standard-size vehicle as a means of constructing a repeated-measures design.

On conceptual grounds, the application of basic behavioral principles to the description and analysis of electronic safety belt reminders should assist in determining the essential conditions for stimulus control. Similarly, Baer, Wolf, and Risley (1968) have suggested that a line of research can "advance best" when it strives for "relevance to principle" (p. 96). For instance, we judge that the stimulus control properties of varying safety belt reminder systems are elucidated by a schedules-of-reinforcement principle (Ferster & Skinner, 1957; Zeiler, 1977) or a multioperant approach (Findley, 1962; Thompson & Grabowski, 1972). Assuming that reminder stimuli are aversive, the differences between the interlock, unlimited, and limited safety belt reminders are essentially one of contingent scheduling. The interlock and unlimited reminder systems are basically a fixed-ratio (FR) 1 avoidance/escape schedule, whereby a driver *must* fasten his or her safety belt to avoid or terminate the safety belt reminder. On the other hand, the limited reminder system is analogous to a concurrent FR 1 fixed-time (FT) 8-s schedule (Findley, 1962; Thompson & Grabowski, 1972; Zeiler, 1977). This concurrent schedule specifies the termination of the reminder signal as a function of the reminder's 8-s duration timing out (i.e., response independent schedule) or a safety belt response occurring before the 8-s reminder interval elapses (i.e., response-dependent schedule).

It is probably the concurrent scheduling, rather than some stimulus feature inherent in the reminder signal itself, such as the type and intensity, that is responsible for the dramatic differences in safety belt use when comparing unlimited and limited safety belt reminders. In the present study, we assessed whether two temporal modifications (i.e., delay and second reminder) would change the effectiveness of this response-mitigating schedule (i.e., limited safety belt reminder) while still complying with the U.S. standard governing the reminder signal's duration and response requirement (Federal Safety Standards, 1971). Hence, at the very least, a schedules-of-reinforcement approach could help researchers who design and test electronic safety belt reminders to differentiate the arrangement of stimulus events, note the presence of response-contingent relations (if they exist), and investigate modifications to a schedule. Behavioral engineers may find particular interest in the notational system developed by Findley (1962). His system, similar to "state notation," is designed to aid the diagramming of behavioral procedures (see also Snapper, Kadden, & Inglis, 1982).

Given the above, future safety belt reminder studies should attend to the articulation of how reminder systems acquire stimulus control. Traditionally, it has been presumed that the limited, unlimited, and interlock reminders were all members of the same class of stimulus control operations, colloquially labeled "prompts" (e.g., Geller et al., 1980). This characterization of all reminder systems conceptually obscures potential stimulus differences among them and inhibits a more precise examination and understanding of the presumed stimulus control operation or underlying principle. For instance, due to their aversive and contingent scheduling (i.e., FR 1, as mentioned above), interlock and unlimited systems may be better described by terms like "establishing operations" (Michael, 1982) or "motivational variables" (Skinner, 1957). On the other hand, because of its weakened contingent scheduling (i.e., concurrent FR 1 FT 8 s), the limited reminder should perhaps be described as an antecedent stimulus with some potential as a discriminative stimulus.

It is unlikely that a safety belt reminder will gain discriminative control through contingency shaping, because the stimulus conditions of the reminder system do not typically occur in the presence of an auto crash nor do auto crashes occur often enough for the reminder system's discriminative potential to be acquired. It has been estimated, for example, that only 1 in 3.5 million person trips end in a fatality and 1 in 100,000 person trips result in a serious injury (Slovic, Fischhoff, & Lichtenstein, 1978). Skinner (1953, 1988), however, has suggested that a culture can establish effective stimulus control by providing its members with a generalized reinforcement history that promotes rule following (i.e., rule-governed behavior). Verbal rules or laws that specify socially contrived contingencies can act to supplement contingencies with consequences that are improbable, such as the consequences related to use or nonuse of safety belts (cf. Hayes, 1989; Malott, 1988, 1989). Rules that gain control may shape new or emergent relations between antecedent stimuli and responses (Blakely & Schlinger, 1987; Brownstein & Shull, 1985; Schlinger & Blakely, 1987). For example, belt use laws and their enforcement may act to establish certain aspects of a vehicle as a discriminative stimulus for safety belt use (e.g., the electronic safety belt reminder) to avoid a traffic fine. Writers of television public service announcements should be persuaded to produce skits that document the enforcement of belt use laws (i.e., the statement of the rule). They could pair a safety belt reminder light and chime with a verbal statement manding "buckle up, it's the law," or a scene in which a police officer is speaking to a driver not using a safety belt, points out the purpose of the reminder light and chime, and then presents a traffic fine for not buckling up. Thus, the effectiveness of a limited reminder as a discriminative stimulus depends on the features of the stimulus, its physical context within a vehicle, and its inextricable cultural context. Today, safety belt promotion devices may have a greater potential than they did 20 years ago, because stronger contrived cultural contingencies regarding safety belt use have been recently employed (e.g., the implementation of belt use laws).

Although more research is clearly needed in this domain, our findings demonstrate that a vehicle's electronic safety belt reminder system can be sufficient to set the occasion for safety belt use among certain individuals. Therefore, we encourage safety belt promoters, policy makers, and auto manufacturers to take a second look at the limited electronic safety belt reminder and potential innovations. Because electronic reminder systems are ubiquitously present in passenger automobiles, vans, and light trucks, their potential importance should be underscored as a large-scale societal intervention or as part of a more general comprehensive cultural mobilization to increase and maintain the use of vehicle safety belts.

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