ALTERING CONTINGENCIES TO FACILITATE COMPLIANCE WITH TRAFFIC LIGHT SYSTEMS

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The effects of altering light pattern sequences on driver compliance at a busy, urban intersection were explored. The baseline light timing sequences resulted in only 46.8% of drivers stopping at the yellow or red lights. Using an A-B-C design, we altered light pattern sequences that increased the probability of drivers stopping at the signals to 88.8% and 98.8%. These findings indicate that traffic light contingencies have potent effects in influencing driver behaviors at busy intersections. Following completion of the study, the traffic engineer approved the permanence of the light timing pattern that increased traffic rule compliance. Accident data collected before and after the light timing changes indicated a reduction in automobile accidents.

DESCRIPTORS: behavioral community psychology, traffic lights, environmental design, prevention

More than 44,000 people were killed in traffic accidents in the United States in 1975 (National Center for Health Statistics, 1979). Given this alarming number, behavioral investigators have begun focusing attention on transportation safety. For example, behavioral scientists have investigated strategies for increasing use of seat belts (Geller, 1983), decreasing automobile speeding (Van Houten, Nau, & Marini, 1980), and promoting safe street crossing behavior (Yeaton & Bailey, 1978). Jason and Liotta (1982) found that different schedules of light timing patterns facilitated either rule compliance or jaywalking among pedestrians.

The goal of traffic planners is to ensure optimal traffic flow (Hobbs, 1979). Unfortunately, the procedures currently used to select traffic control equipment are limited and lack uniformity (Tarnoff, Voorhees, & Parsonson, 1980), and most of the research has been conducted at isolated intersections (Leisch, Pfefer, & Moran, 1967; Vodrazka, Lee, & Haenel, 1971; Zador, Stein, Shapiro, & Tarnoff, 1984). For example, Perkins and Harris (1968) documented 20 different situations which had high potential for accidents; however, they all focused on only one intersection and traffic light control system. Several investigators have ex-

amined drivers' patterns of approach to yellow and red lights at isolated intersections (Evans & Rothery, 1976; Freedman, 1975); and some investigators have found that if drivers are close to an intersection when the light is turning from yellow to red, a high percentage will not stop (Konečni, Effesen, & Konečni, 1976; Parsonson, 1978; Williams, 1977).

All the just-noted studies were conducted at single, isolated intersections. We could find no study which examined two separate light systems located close to each other, where the effects of these separate light patterns might influence driver behavior. We examined contingencies in this more complex setting, in an effort to identify and alter potentially dangerous light timing sequences.

METHOD

Setting

We conducted the study in Chicago at a site that had two traffic light systems relatively close to each other (see Figure 1). Traffic lights 1 and 2 (T1 and T2) were 45.1 m apart on the experimental (E) street where light timings were altered. Of 191 cars approaching T1, 69% also eventually passed T2. (Two independent observers counted the number of cars turning versus going straight. Interrater reliability for 20 trials was 100%). The light at T1 was green for 19.7 s. Two independent

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Figure 1. Diagram of the intersection and light timing sequences.

observers with stopwatches timed 10 occurrences of the green arrow being on. Interrater reliability was 94% (for light timing calculations, the smaller number was divided by the larger number for each trial). After T1 turned green, T2 turned yellow in 10.7 s (interrater reliability for 10 occurrences was 92%), and red 3 s later (interrater reliability for 10 occurrences was 100%). (See Figure 1.) The first car passing T1 took an average of 10 s to reach T2, the second car an average of 12.5 s, and the third, 15.6 s. (Interrater reliability for 10 episodes of the first car was 92%; for 10 episodes of the second car, 93%; and for the third, 96%.) Only the first three cars were observed because there were only three independent lanes in front of T2, and only the first three cars had an opportunity to proceed through the intersection. If all three did stop, then the fourth car probably would not have been able to pass through T2. The first car approaching T2 usually proceeded through on green; however, the second and third cars were confronted with either a yellow or a red light. Traffic light 3 (T3) on the control (C) street was 40.1 m from T2. The light timing sequence was such that when T3 turned green, T2 turned green 2.7 s later. When T3 turned red, T2 remained green.

Procedure

Observations occurred between 4:45 and 5:15 p.m. (X on Figure 1). Each day of observations, the intersection was observed for 30 trials (a trial was defined as the time period extending from the beginning of green at T1 to the end of the red at T1). Experimental and control trials were alternated. Throughout the study, an average of 72 experimental cars were observed daily traveling from T1 to T2. During each trial, an average of three other cars departing from T1 followed the third target car, but these cars were deleted from the analysis because they all stopped at T2. An average of 373 cars were observed during each day of data collection traveling from T3 to T2. As the front of each car went over the T2 stop line, or came to a complete stop before it, the observers would note whether the T2 light was on green, yellow, or red. The observers also recorded whether or not the car passed through the T2 intersection.

The primary dependent measure was the percentage of cars stopping on red or yellow (number stopping for red or yellow divided by the number reaching T2 on the red or yellow).

During each of 30 trials, an observer recorded traffic from T1 to T2. When the green light appeared at T1, there were always at least three cars waiting at T1. The observers noted whether the first car reached T2 at the green, yellow, or red, and whether or not the car proceeded through the intersection. If a car at T2 was delayed from traveling because another car was making a turn, these data were deleted. When the T1 light turned red, a short time later, the T3 light turned green. When the cars passing T3 reached T2, the observer noted whether each car stopped or proceeded through the intersection and the light condition when passing the stop line at T2.

Reliability

There were four reliability sessions conducted, at least one during each phase of the study. To be scored as an agreement, the two observers, standing 2 ft apart, had to score their sheets independently with a similar code under a similar light condition. Reliability was calculated using the formula: $\text{agreements}/(\text{agreements plus disagreements})$. For control data, the smaller number of observations (from one observer) would be divided by the larger number of observations from the second observer.

Experimental Design

An A-B-C design was used. During a 2-week period in 1982, baseline data were collected for 5 days. Approximately 1 year later, in a sixth observation session, two observers calculated reliability data on all the light patterns described previously. Reliability was >90% for all variables, and the data collected at Day 6 were comparable to data collected from Days 1 to 5.

Five days of data were collected for both Time Change 1 and 2. Each time change occurred during a 2-week period, and both time changes immediately followed the sixth observation session. Both time changes involved having the light-timing sequence at T2 altered. Immediately after onset

Figure 2. Percentage of drivers stopping their cars on yellow or red light.

of both Time Change 1 and 2, two observers reassessed reliability for all light timing sequences. For all variables, reliability was $\geq 90\%$. During the baseline, after T1 turned green, T2 turned yellow in 10.7 s (see Figure 1). For Time Change 1, this was reduced to 7.3 s; for Time Change 2, 5.1 s.

RESULTS

Average interrater reliability for the experimental observations (the first, second, and third car

either stopping at T2 on yellow, red, or green, or going through the intersection) was 98% (range 95% to 100%). Average interrater reliability for the control observations was 100% (range 99% to 100%). Reliabilities were obtained on 25% of the sessions.

Figure 2 presents data on the percentage of experimental cars that stopped on either yellow or red. During baseline, an average of 46.8% of cars stopped. This rate increased to 88.8% and 98.8% for Time Change 1 and 2, respectively. For the

control street, no cars were observed not stopping on the red or yellow.

Accident data provided by the Deputy Commissioner, Chicago Department of Public Works, indicate that during a 7-month period (February to September 1983) before the time change interventions, there were 22 accidents at the intersection. From February to September 1984, after Time Change 2, accidents had decreased to 14.

DISCUSSION

We found that different patterns of traffic light timings influenced drivers' behavior when traversing an intersection. In Chicago, the traffic light patterns were established by taking into consideration two variables: traffic volume and the number of lanes available. Traffic engineers have estimated the amount of time it takes for traffic to move through an intersection, allowing 5 s for the first car and 2.5 s for subsequent cars. However, such an analysis does not take into account possible problems when two light systems are close to each other. For example, in our study, during baseline, in the 10.7-s interval between T1 turning green and T2 turning yellow, a high percentage of drivers went through the yellow and red lights at T2.

After waiting at one light, drivers proceeded to a second system, which was in the process of changing light signals. Although the first driver usually proceeded on green, the second and third drivers were confronted with yellow lights or recently changed red lights. These drivers previously had waited up to 42 s at the first light system, and at the second light system were confronted with the prospect of waiting another 42 s. Traffic lights are discriminative stimuli for either proceeding (green), stopping (red), or slowing down or speeding up (yellow). They also represent a hazard (red) in the form of collision or arrest, or a reinforcer (green) in the form of getting closer to the end of the trip. During yellow (caution) the driver is confronted with an approach-avoidance conflict, and by having the yellow and red lights occur earlier, the conflict was reduced for most drivers, and most stopped before the intersection.

It could be argued that a more appropriate dependent measure would have been the percentage

of drivers running the red light, a clear traffic rule violation, as opposed to the combined red and yellow. When a yellow light appears, drivers are warned that they should slow down. The results of our study remain equally valuable when the focus is on those drivers running red lights: for baseline 16%; Change Time 1, 3%; and Change Time 2, 0%.

The traffic engineer of Chicago fully cooperated with us in conducting this study. The fact that the engineer was pleased with the results is reflected in his decision to maintain permanently the light-timing sequence of Change Time 2 and in his request to the first author to help document light timing sequences at another intersection in Chicago with extremely high accident rates.

The aversive properties of delays in reinforcement schedules have been documented in laboratory studies (Honig & Staddon, 1977). Some types of traffic timing patterns reduce the probability of drivers proceeding through yellow and red, whereas other contingencies seem to increase the probability of this behavior. More than likely, these types of contingencies operate in diverse settings and may produce either salutary or deleterious outcomes. Behavior analysts have much to contribute in assessing these contingencies, and demonstrating their effects on behavior.

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Received May 31, 1984

Final acceptance October 22, 1984