

EVALUATION OF ALTERNATIVE DATE DISPLAYS FOR ADVANCE NOTIFICATION MESSAGES ON PORTABLE CHANGEABLE MESSAGE SIGNS IN WORK ZONES

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ABSTRACT

In this paper, the results of a laptop-based human factors study of alternative formats of presenting notice of future roadwork messages on portable changeable message signs (PCMSs) in highway work zones are documented. A total of 192 participants across Texas were shown a series of different two-phase messages for a fixed period of time and asked questions by test administrators as a means of determining comprehension and recall of the information presented in each message. Participants were also asked to indicate their preferred format for presenting such information on a PCMS.

Based on these studies, the authors recommend that messages that require the display of calendar dates for future roadwork and other traffic control activities should utilize a message format consisting of the three-character abbreviation of the month (e.g., APR for April) in conjunction with the date. When future work activities span several days all in the same month, the month needs to be noted only once in the message (i.e., APR 21-23) rather than repeating the month (i.e., APR 21-APR 23).

INTRODUCTION

A portable changeable message sign (PCMS) can be an effective tool for communicating with drivers, particularly in a roadwork situation. However, displaying messages that are too long for drivers to read at prevailing speeds, or that are too complex or inappropriately designed leading to driver confusion, can adversely affect both traffic flow through a work area and a transportation agency's credibility. Therefore, incorporation of fundamental message design principles is a key issue for ensuring that valuable information is understood by drivers (*1*).

One message design issue that has arisen is how to effectively provide advance notice of changes in traffic conditions in a work area. The Texas Department of Transportation (TxDOT) has a policy which requires that drivers be provided more than seven days notice about upcoming lane closures and other major traffic control changes on high-volume roadways. In some cases, advance notice messages are presented for several weeks prior to the actual work activity being performed. PCMSs are often used for this purpose. However, this application does not allow the sign operator to simply use day of the week indications, as is recommended in existing dynamic message sign message design guidelines (*1*). Rather, it is necessary to convey the actual date of the future work activity. The objective of this study was to determine whether days of the week and date information could be interpreted together, and if so, then the manner in which date references should be included in a message. Study questions include those listed below.

- What should be the order of days of the week and dates when they are in the message (i.e., days, then dates, or vice-versa)?
- How should dates be formatted (APR 21 versus 4/21)?
- Should the month always be included before each date (APR21-APR25 versus APR 21-25)?
- Can drivers recall certain types of schedule information better than others (dates, times, etc.)?
- Can drivers determine if a date displayed applies today?
- Can drivers determine if a date applies to travel planned in the future (i.e., if the message relates to travel on that road one week from tomorrow)?

In this paper, the methodology and results are presented of a laptop-based laboratory study conducted to address these questions. Additional details concerning the overall project can be found elsewhere (2).

STUDY BACKGROUND

Dudek reported on studies conducted in New Jersey to evaluate messages displaying times of day, days of the week, and month dates (3). He found that drivers have difficulty relating calendar dates (e.g., Sep 25-Sep 28) to specific days of the week. Only 11 percent of the participants were able to give the correct days of the week when calendar dates were displayed. When days of the week were displayed, 97 percent of the study participants gave the correct days. Dudek, et al. conducted a similar study in Texas in the cities of Dallas, El Paso, Fort Worth, Houston, and San Antonio. Only 21 percent of the participants correctly identified the days of the week when calendar dates were shown in the message (4).

These results led Dudek et al. to recommend that days of the week be used in a DMS message rather than calendar dates (1). However, given current TxDOT policy of displaying advance information more than seven days prior to the roadwork, this current study was designed to provide improved guidance on including calendar date information in a message when it is necessary to do so.

STUDY APPROACH

A laboratory study was conducted in six cities in Texas (Austin, Arlington, Laredo, San Antonio, El Paso, and Houston). The study involved the use of a laptop computer programmed with software developed at the Texas Transportation Institute (TTI) to evaluate alternative PCMS and dynamic message sign (DMS) messages. The software allows display of one- or two-phase messages of fixed duration. In addition, a secondary task loading activity in which study participants monitored and clicked on buttons that appeared in a control panel at approximately one-second intervals. This secondary task was used to simulate the effects of attention-sharing and task loading that are required while operating a vehicle under moderate driving demands such as exists in typical work zone situations. While it was not possible within the limitations of this study to actually calibrate this secondary task loading level to the attention-sharing demands of a specific driving condition, it is believed that the introduction of the secondary task itself into

the study design does improve the applicability of the results relative to actual driving situations. A participant of the laptop study is illustrated in Figure 1.



Figure 1. Laptop Study Participant.

There were two sessions to the study. Session 1, Fixed Viewing Time, involved an experiment in which the participants were presented messages displayed for a total of eight seconds, which is approximately the viewing time available to a typical motorist approaching an 18-inch character LED PCMS at 55 mph. Session 2, Preference, involved participants looking at alternative messages side-by-side and indicating their preferred alternative. As shown in Table 1 (configured for the San Antonio study), the message set consisted of four messages along with an alternative for each. In addition, Message 5 consisted of a message containing the date, day, and time and was probably much longer than what could be read and recalled by drivers, but was considered worth testing. The dates and roadway names and numbers were changed for each survey location to reflect local routes and upcoming calendar days and dates. The messages were two phase and cycled through the message twice during the fixed time limit of eight seconds. Thus, each phase appeared for two seconds at a time. The order in which the messages were viewed was counterbalanced among two groups of participants, Group A and Group B. Each group consisted of 16 participants per study location balanced according to age, education,

and gender. Group A viewed Message Set A, while Group B viewed the alternative message. The actual roadway locations and dates displayed were changed in each study location. A total of 192 participants participated in the study, 32 at each study location.

Table 1. Test Messages from San Antonio.

Message Set	Group A Messages		Group B Messages	
	Phase 1	Phase 2	Phase 1	Phase 2
1	ALT LANES CLOSED	4/21 TO 4/25	ALT LANES CLOSED	APR 21 TO APR 25
2	I-410 W EXIT CLOSED	MON APR 27 9AM-3PM	I-410 W EXIT CLOSED	APR 27 9AM-3PM
3	LEFT 2 LANES CLOSED	MON-FRI APR25- APR29	LEFT 2 LANES CLOSED	MON-FRI APR25-29
4	1-410 W ROADWORK	MAY17- MAY19 TUE-THUR	I-410 W ROADWORK	MAY17- MAY19 10AM-6PM
5	ALT LANES CLOSED	MAY9-11 MON-WED 11AM-8PM		

With two-phase messages, it is possible that some drivers will first see the message during the second phase. To account for this possibility, Group A was subdivided into Groups A1 and A2 with eight participants each, balanced according to age, education, and gender as much as possible. Group B was also subdivided into Groups B1 and B2 with eight participants each. The participants in Group A1 and Group B1 saw the messages starting from the first phase. The participants in Group A2 and Group B2 saw the messages starting from the second phase. The secondary task loading activity began 8 seconds before the message was displayed and continued through the presentation time of each message. The secondary task loading level was held constant for all participants throughout the study.

STUDY RESULTS

Message Set 1: Numeral Month versus Text Month

As illustrated in Table 1, Message Set 1 provided direct comparison of participant recall and comprehension of messages utilizing only numerals for upcoming calendar dates (i.e., 4/21 for

April 21) to messages using text to indicate the month (i.e., APR 21). Recall and comprehension of information were examined in both phases of the message. In addition, each participant was queried whether the message indicated that the work activity was occurring on the day the study was performed or would be occurring 8 days later (i.e., one week from tomorrow) should they be traveling that facility.

The percent correct recall of both the problem (alternate lanes closed) and dates of the lane closure by study participants are summarized in Table 2. Both formats resulted in similar percentages of correct responses of the problem and calendar dates, at or near 85 percent recall levels. Interestingly, however, the text and numeral date format (Message Format B) yielded more correct responses to the question “does this message indicate that work activity is occurring today?” Whereas 92 percent of the participants viewing the text and numeral format correctly responded to this question, only 72 percent of the participants viewing the numeral date format responded correctly. This difference was highly significant ($p\text{-value} < 0.001$). On the other hand, both formats yielded similar response rates to the question “does this message indicate that work activity will be occurring one week from tomorrow?” As shown in Table 2, 79 percent of participants viewing Message Format A (numeral month) correctly identified whether work would be occurring one week from tomorrow, compared to 81 percent of the participants viewing Message Format B (text month). The differences cannot be considered to be significant ($p\text{-value} = 0.730$).

Study results also indicated strong participant preference for the date and numeral format for calendar dates over the completely numeral format (83 percent versus 17 percent, respectively). The most common reason given for preferring the text and numeral format was that it was much easier to view and comprehend as a calendar date. Interestingly, neither format resulted in participants being able to convert the calendar dates into the specific days of the week that work would be occurring. This result is consistent with previous research by Dudek (3,4). Only 13 percent of the participants who viewed the numeral format for month and date (Format A) could indicate the days of the week for which the message would be valid. Similarly, the only 12 percent of the participants viewing the message utilizing a text/numeral format for the month and date (Format B) could indicate the days of the week for which the message would be valid.

Table 2. Driver Responses to Message 1 Comparisons.

	Group A Message: Numeral Month	Group B Message: Text Month	Difference Level of Significance^a
Correctly Recall Problem?	78%	88%	0.066
Correctly Recall Dates?	88%	84%	0.426
Correctly Recognize if Activity is Today?	72%	92%	< 0.001
Correctly Recognize if Activity is 1 Week from Tomorrow?	79%	81%	0.730
Correctly Identify Days of the Week of Activity?	13%	12%	0.834
Format Preferred?	17%	83%	<0.001

^a based on a test of proportions

Message Set 2: Calendar Dates with and without Day of Week Included

As indicated in Table 1, Message Set 2 was designed to assess how the addition of day-of-week information influenced participant abilities with regard to information recall and comprehension. The addition of day information could presumably facilitate interpretation of calendar date information for those messages about future events. Time information about the activity (9AM – 3PM) was added to this message set to allow testing under a higher information load condition.

The results of the study for Message Set 2 are given in Table 3. The addition of day information (Group A Message) did not degrade participant ability to recall the problem from the message. Correct recall of the problem was 33 percent when the day of the week was included in the message (Group A Message), compared to 35 percent without the day information presented (Group B Message).

The inclusion of day information did not result in different recall rates of the calendar date (58 percent for Group A Message versus 65 percent for Group B Message), or the times of activity (30 percent for Group A Message versus 26 percent for Group B Message). The authors did note a significant difference in the percent of participants who could identify the day of the week that work would occur. Whereas 44 percent of participants who viewed Group A Message could identify the day of week, only 29 percent of participants viewing Group B Message could do the same. It was expected that such a difference would exist, given that the Group A Message

actually included the day of week. However, the fact that only 44 percent of those participants could recall that information suggests that many participants were overloaded with the information presented and could not properly recall it after viewing the message.

Strangely, the message that did not include day information (Group B Message) actually yielded a higher percentage of correct responses to the question “does this message indicate that work activity is occurring today?” than did the Group A Message. Eighty-three percent of the participants viewing the Group B Message correctly responded to this question, compared to only 67 percent of participants who viewed the Group A Message. Meanwhile, the percent of participants who could correctly determine whether work would be occurring one week from tomorrow was also slightly higher for Group B Message (76 percent) than for the Group A Message (65 percent).

Table 3. Driver Responses to Message 2 Comparisons.

	Group A Message: Day, Date, and Time	Group B Message: Date and Time Only	Difference Level of Significance^a
Correctly Recall Problem?	33%	35%	0.770
Correctly Recall Dates?	58%	65%	0.320
Correctly Recall Times?	30%	26%	0.538
Correctly Recall Day?	44%	29%	0.031
Correctly Recognize if Activity is Today?	67%	83%	0.011
Correctly Recognize if Activity is 1 Week from Tomorrow?	65%	76%	0.096

^a based on a test of proportions

Message Set 3: Repeating Month Information in the Message

In Message Set 3, the research team examined whether advance notice messages that span several days in the same month should repeat the month before each calendar date, versus only indicating the month once. Eliminating the replication of the month information does save space in the message, but may make it more difficult for drivers to assimilate the date information.

Days of the week were also included in this message set to keep the overall information load at a fairly high level.

The results of the Message Set 3 study are presented in Table 4. Overall, the results of this particular part of the study were mixed. On one hand, the replication of the month information in the Group A Message did not yield significantly higher recall of the reported problem (64 percent) than did the information in the Group B Message (52 percent), days of work (63 percent for the Group A Message, 72 percent for the Group B Message), or dates (68 percent for the Group A Message, 56 percent for the Group B Message). Similarly, there were not significant differences in the ability of participants to recognize if the activity is occurring today (84 percent for the Group A Message versus 76 percent for the Group B Message) or occurring one week from tomorrow (72 percent for the Group A Message 73 percent for the Group B Message). However, an overwhelming preference for the Group B Message over the Group A Message was found (93 percent versus 7 percent, respectively). Participants strongly indicated that they preferred not having to read the same month twice in the message.

Table 4. Driver Responses to Message 3 Comparisons.

	Group A Message: Month Repeated	Group B Message: Month Not Repeated	Difference Level of Significance^a
Correctly Recall Problem?	64%	52%	0.093
Correctly Recall Days?	63%	72%	0.184
Correctly Recall Dates?	68%	56%	0.088
Correctly Recognize if Activity is Today?	84%	76%	0.167
Correctly Recognize if Activity is 1 Week from Tomorrow?	72%	73%	0.877
Format Preferred?	7%	93%	<0.001

^a based on a test of proportions

Message Set 4: Including Days versus Times in a Message

As can be seen in Table 1, the purpose of the evaluation of Message Set 4 was to determine whether there were any differences in message comprehension and preference between providing

day information or time information in conjunction with date information in advance notification messages on a PCMS. The results of the evaluation of this message set are shown in Table 5. Overall, the substitution of work activity times for days of the week in the message had no appreciable effect on the participants' ability to correctly comprehend the problem, calendar date, or in determining whether work would take place on the roadway today or one week from tomorrow. Interestingly, the participants preferred time information to be included in the message, even though most could not correctly recall that information from the message. Most participants could not correctly recall the day either when presented that information in the message.

Table 5. Driver Responses to Message 4 Comparisons.

	Group A Message: Day Information Included	Group B Message: Time Information Included	Difference Level of Significance^a
Correctly Recall Problem?	52%	49%	0.678
Correctly Recall Days?	42%	---	---
Correctly Recall Times?	---	39%	---
Correctly Recall Dates?	61%	55%	0.401
Correctly Recognize if Activity is Today?	86%	80%	0.270
Correctly Recognize if Activity is 1 Week from Tomorrow?	72%	73%	0.877
Format Preferred?	21%	79%	<0.001

^a based on a test of proportions

Message Set 5: Inclusion of Day, Date, and Time Information in Message

The evaluation of this final message type further explored the ability of drivers to assimilate and comprehend a large amount of information about an upcoming work activity. The message was similar in style to those used in Message Set 2, but included a range of calendar dates and days rather than the single day and date previously tested. Consequently, Message Set 5 contains the

greatest amount of information among the messages tested. This Message Set was tested on all 192 participants.

The results of this message set evaluation are presented in Table 6. Overall, participant recall rates of the various information units in the message ranged between 7 and 85 percent. It is interesting to note the order in which participants did remember the information in the message. The problem statement (ALT LANES CLOSED) was remembered most often, followed by day information. Only 29 percent of the participants correctly recalled the dates included in the message, and only 7 percent could correctly recall the times of work that were specified in the message. Based on the information they processed from the message, 70 percent of the participants correctly identified whether the message meant that work was occurring that day. Similarly, 69 percent were able to correctly determine whether the message indicated that work would be occurring one week from tomorrow.

Table 6. Driver Responses to Message Set 5.

	Day, Date, and Time Information Included
Correctly Recall Problem?	85%
Correctly Recall Days?	47%
Correctly Recall Dates?	29%
Correctly Recall Times?	7%
Correctly Recognize if Activity is Today?	70%
Correctly Recognize if Activity is 1 Week from Tomorrow?	69%

INTERPRETATION OF RESULTS

Based on the results of the laptop study, the following inferences regarding the presentation of advance notification information about future roadwork and other traffic control activities on PCMS were drawn:

- The results validated previous research findings that most drivers cannot identify specific days of the week of the road work activity when calendar dates are displayed.
- Messages that require the display of calendar dates for future roadwork and other traffic control activities should utilize a message format consisting of the three-character abbreviation of the month (i.e., APR) in conjunction with the date. This format appears to be somewhat easier for drivers to interpret than using all numerals for both month and date, and was the greatly preferred format during participant driver testing.
- When future work activities span several days all in the same month, it appears appropriate to only indicate the month once in the message (i.e., APR 21-23) rather than repeating the month (i.e., APR 21-APR 23). The former is shorter and easier to incorporate into a PCMS message. Additionally, repeating the month before each date does not significantly improve participant comprehension and recall, and drivers overwhelmingly prefer the single-month format. Of course, if the work activity will span two months, both months have to be included in the message.
- Attempts to present day, date, and time information about upcoming roadwork activities appear to exceed the upper limit of information processing capabilities of many drivers. Very low comprehension and recall rates were found for some of the message elements when this type of information was presented together in a two-phase PCMS message. However, participants appeared to naturally retain day information easier than time information, when both are included in the message.
- Regardless of the format used, only about three-fourths of the drivers viewing the PCMS message were able to correctly interpret whether the work activity noted in the message will affect their current trip or a future trip.

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