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AGE DIFFERENCES IN COMPREHENSION OF AFFIRMATIVE AND NEGATIVE INFORMATION IN VERBAL AND SYMBOLIC TRAFFIC SIGNS

A Thesis

Presented to the

Faculty of

California State

University, San Bernardino

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Psychology

---

by

Sharon Lee Morey

June 1987

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ABSTRACT

The rapid growth in foreign travel and trade in the past twenty years and the resulting need to convey important information to people in a manner that is independent of their language and culture has led to a growing trend toward replacing verbal sign messages with symbolic ones. Previous studies have investigated whether a verbal or a symbolic sign is more easily recognized under conditions of good and poor visibility, at high speed and at great distances, or have attempted to identify an accurate and efficient method for choosing a symbolic representation that most accurately conveys its intended message. Although it is a well documented finding that spatial abilities decline at a faster rate with age than do verbal abilities, few studies have investigated the impact of the change to symbolic signs on the elderly. An additional factor that has not been given due consideration by investigators is how people process a symbolic negative. Using a matching to standard reaction time (RT) paradigm, this study examined the ways in which younger and older female drivers process verbal and symbolic negative and affirmative information. Four types of regulatory traffic signs were used as stimuli: 1) verbal affirmative; 2) verbal negative; 3) symbolic affirmative; and

4) symbolic negative. Signs were viewed through a tachistoscope and both comprehension RT and matching RT were measured. A measure of mean motor response time was taken at the beginning of the experimental session and used as a covariate in all analyses. As expected, younger subject's response times to all stimuli were faster than older subjects' even when adjusted for motor response time. Matching RT was faster than comprehension RT, responses to verbal stimuli were faster than to symbolic stimuli, and responses to negative signs were faster than responses to affirmative signs for all subjects. All subjects found matches easiest to make when match and standard were in the same verbal-symbolic dimension. Symbolic matches to a verbal standard were more difficult than verbal matches to a symbolic standard for both age groups. More research is needed for finding the symbolic representation that most accurately conveys the intended message of a traffic sign. An investigation of how people process symbolic directional information is also needed.

ACKNOWLEDGMENTS

The preparation of a thesis is something that must be done by oneself but that would also be difficult, if not impossible to do alone. I have certainly received far more than my share of support, encouragement and help as I have made my way through this "culminating experience." Diane Halpern's belief in me made it possible for me to do what otherwise I would never have dared to try. For that I will be forever grateful. David Riefer gave me hours of his time and help as we went through revision after revision. Laura Kamptner and David Lutz were also always available to give me advice and encouragement. Certainly without the expertise and willing assistance of Bruce Clemmens and Gratice Brown this experiment would never have gotten past the planning stages. And of course I shall be forever grateful to Jan Kottke for giving up three hours of her Saturday afternoon to help me figure out how to get my data analysis to run. That was certainly above and beyond the call of duty.

My fellow students also helped to make this experience not only bearable, but even fun at times. Kalin Anderson and Bonnie Hoffman spent hours looking at traffic signs without complaining. Maggie Dragna and Barbara Zigalo were wonderful in guiding me through the maze of the computer center and trying to explain to me how computers "think." So was Randy McCauley, who came in looking for a stapler and ended

up spending the entire afternoon.

Diane Pfahler's support was especially important to me. How fortunate for both of us that our "down" days never coincided.

Finally, I want to thank my family for their faith, encouragement, and especially for their patience. Without the four of you, I couldn't have done any of what I have accomplished in the past two years. And without the four of you in my life none of it would mean much anyway.

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INTRODUCTION

In recent years there has been a growing trend toward replacing verbal sign messages (e.g., gasoline, restroom, telephone) with symbolic ones. Symbolic signs are usually "pictographs" which convey the intended message. For example, large orange signs with "Men Working" printed on them are being replaced with signs that show the silhouette of a male figure, presumably shoveling dirt or gravel from a pile.

The change to symbolic messages is occurring in a wide variety of contexts including roadway traffic signs, public information signs in such places as airports and convention centers, and in the labeling of gauges and switches on the instrument panels of automobiles (Dewar & Ells, 1974; Halpern, 1984). The increasing use of symbolic signs is occurring in response to the rapid growth in foreign travel and trade in the past twenty years and the resulting need to convey important information to people in a manner that is independent of their language and culture (Caron, Jamieson & Dewar, 1980).

In addition to these factors, there are also safety considerations, particularly in the use of symbolic traffic signs. It has been suggested that symbolic messages can be

more quickly and easily recognized than verbal messages under conditions of both good and poor visibility (Ells & Dewar, 1979), that they are also more quickly identified at high speed (Dewar & Ells, 1974) and at greater distances (Ells & Dewar, 1979). Testin and Dewar (1981) identify a "better" sign as one that has a greater legibility distance (i.e., it can be identified from farther away) and a smaller reaction time than another. Based on these criteria, Testin and Dewar (1981) suggest that warning signs are better than regulatory signs and symbolic signs are better than verbal signs. A warning sign is a yellow, diamond-shaped sign which carries a message such as "Slippery When Wet." Regulatory signs are white rectangular signs which carry such messages as "No Left Turn." Testin and Dewar (1981) also found that legibility distance for regulatory signs does not differ significantly between verbal and symbolic versions of the same sign.

There is some concern about the abstraction of the intended meaning from symbolic signs and at least one study (Caron, Jamieson, & Dewar, 1980) has been conducted in an effort to determine an accurate and efficient method for choosing a symbolic representation that most accurately conveys its intended message. Caron et al. (1980) used the semantic differential paradigm to assess the similarity of meaning of pictographs to their intended verbal message. Their results indicated that the degree to which a given

symbol and its intended message occupy the same semantic space is significantly correlated with sign comprehension, reaction time and glance legibility. Glance legibility is defined as the ease with which a sign's meaning can be determined when the sign is seen for only a brief amount of time.

Elderly Drivers

Although a number of studies have been conducted to assess the relative merits of verbal and symbolic traffic signs, few have investigated the impact of the change to symbolic traffic signs on the elderly driver. Halpern (1984) found that although elderly drivers responded more slowly than did younger drivers to both verbal and symbolic traffic signs, the older drivers responded an average of .2 seconds more quickly to verbal than to symbolic traffic signs. It is a well established finding that although cognitive abilities decline in old age, they do not decline at the same rate. Verbal abilities remain high into old age, whereas spatial abilities begin to decline somewhat earlier (Matlin, 1983). Winograd and Simon (1980), for example, have found that memory for pictures declines faster than memory for words, so that visual imagery may be more difficult for the elderly.

In a 1983 study using a mental rotation task, Clarkson-Smith and Halpern found that older subjects made significantly fewer errors when the picture to be rotated was accompanied

by a verbal directional label, suggesting that verbal strategies can be used by the elderly to offest the age-related decline in their spatial abilities. In a study designed to assess possible age-related differences in speed of accessing semantic memory from a verbal or a pictorial stimulus, Mergler and Zandi (1983) found support for the hypothesis that verbal coding becomes increasingly dominant throughout adulthood. Mergler and Zandi (1983) suggest that verbal stimuli activate pictorial images even before being systematically processed but pictorial information cannot be labeled (or compared to other incoming information) until it is completely processed. Mergler and Zandi (1983) suggest that verbal information facilitates older adults' performance, particularly when speed and accuracy are important goals (such as during driving).

The major finding of a study by Poon and Fozard (1978) was that the names of pictures that were relatively more familiar to members of an age cohort were retrieved more rapidly and accurately from long-term memory by members of that cohort. Their data provide direct support for the hypothesis that the major determinant of speed of retrieval of information from long-term memory is familiarity of the information. It is therefore arguable that when today's younger drivers reach old age they may be more familiar with symbolic traffic signs than are today's older drivers since symbolic signs will have been in use for all of their driving

years. Any age-related increase in reaction time to symbolic traffic signs might therefore be expected to diminish or to disappear as succeeding cohorts become more familiar with symbolic traffic signs. Schaie and Strother (1968) suggest that age changes over time within the individual are much smaller than differences between cohorts. Findings on longitudinal age changes suggest further that levels of functioning attained at maturity may be retained until late in life except where decrement in response strength and latency interferes. It is because this study is concerned with the impact of the change to symbolic signs on today's older driver that a cross sectional design has been chosen.

Interpreting Negative Information

An additional factor that has not been given due consideration by investigators is how the driver processes traffic signs that contain a negative component. In a verbal traffic sign the negative component would be the word "no" or "not" as in "No Right Turn" or "Not a Through Street." In a symbolic traffic sign the symbol would be circled and slashed through in red. It is well documented that cognitive processes handle positive information better than negative information (Matlin, 1983). Negatives are difficult because they require an additional complicated translation (Akiyama, Brewer, & Shoben, 1979; Clark & Chase, 1972).

Although negatives in signs have not been studied

specifically, negatives have been used as stimuli in other investigations. The results of Ells and Dewar's (1979) study indicated that warning signs take less time to comprehend than regulatory signs. However, 75% of the regulatory signs sampled contained a negative component, whereas all warning signs sampled were affirmative in nature. It is possible that the difference in reaction time between warning and regulatory signs is an artifact because most regulatory signs studied are negative.

Mergler and Zandi (1983), using a matching paradigm, found that the presence of a negation enabled subjects to process only the negation and not the entire message carried by the sign. The matching paradigm allowed subjects to utilize a short-cut strategy that eliminated the translation of one mode of processing into another. It is not clear whether in Mergler's and Zandi's (1983) study the choices for a negative standard consisted of two negative samples or of both a negative and an affirmative sample.

A consideration of the present study is an investigation of how drivers process traffic signs containing a negative component.

Reaction Times

By comparing the results of a field study under actual driving conditions and reaction times in laboratory studies, Dewar, Ells, and Mundy (1976) concluded that reaction time

is a valid index of the comprehension of traffic sign messages. Two separate reaction times were measured in this study. The first reaction time was the time required for the subject to comprehend the message of a visually presented verbal or symbolic traffic sign. The second reaction time was the time required for the subject to determine which of two visually presented traffic signs matched the message of the previously presented referent traffic sign. Because Gottsdanker (1982) found a significant age difference for a key-press response, a measure of each subject's mean simple reaction time was taken at the beginning of the experimental session and this mean reaction time was covaried with each subject's comprehension reaction time and matching reaction time in order to minimize differences that are due only to the age difference in motor response.

A matching task, which can be conceived of as a test of recognition memory, is used in this study. Compared to recall memory, recognition memory has been shown to decline less as people grow older (Perlmutter, 1979; Schonfield & Robertson, 1966). Therefore, an older and a younger person should differ on the reaction time measures only in the amount of time each one takes to abstract information from the presented stimuli and make the key-press response and not on some long-term memory component.

Hypotheses

It is expected that the response times of older subjects to all stimuli will be slower than those of younger subjects because of the relative complexity of the matching task. Cerella, Poon, and Williams (1980) found that more complex tasks result in greater performance deficits for the elderly. Cerella et al. (1980) saw two levels of deficit in their data, a slight slowing on sensorimotor tasks and a more severe slowing on tasks involving mental processing.

Older subjects are expected to respond more slowly to symbolic signs than to verbal signs because of the differential decline with age of verbal and spatial abilities (Halpern, 1984; Matlin, 1983; Winograd & Simon, 1980).

Responses to a symbolic match are expected to be faster for all subjects when the standard is verbal than when the standard is symbolic. This finding would lend support to Mergler and Zandi's (1983) suggestion that verbal stimuli activate pictorial images even before being systematically processed but pictorial information cannot be labeled (or compared to other incoming information) until it is completely processed.

All subjects are expected to respond more slowly to negative matches paired with negative distractors than to negative matches paired with affirmative distractors. The pairing of a negative match and a negative distractor would prevent the use of the short-cut strategy of processing

only the negative rather than the entire sign message.

METHOD

Subjects

Subjects were women from two age groups. Older subjects were women living independently in a retirement community located in a suburban area of Southern California. The older women were between the ages of sixty-five and seventy-five, with a mean age of 72.6 years. All older subjects were required to have a current driver's license and to have been actively driving for the past two years. The mean number of years of driving experience for the older women was 49.9 years, with a range of forty to sixty-one years. The older subjects all reported general good health. All of the older women had attended at least two years of college.

The younger subjects were drawn from undergraduate psychology classes at a small Southern California state university. The younger women were between the ages of eighteen and twenty-eight, with a mean age of 22.25 years. The younger women were also required to have a current driver's license and to have been actively driving for the past two years. The mean number of years of driving experience for the younger subjects was 6.35 years, with a range of nine to thirteen years. All of the younger women had attended at least two years of college.

Apparatus

Traffic signs were viewed through an Iconix 1408 tachistoscope controlled by an Apple IIe computer. A program was written in Applesoft Basic for the computer, which allowed it to set up conditions, measure reaction times, and record errors and response times. Data were automatically recorded on a tape produced by a Coulbourn R22-10 printout counter connected to the computer. Subjects were seated in front of a table which held a three-key response panel. They were instructed to rest the index finger of the dominant hand on a raised dot that was equidistant from all three response keys, which were arranged in a semicircular array around the raised dot. Subjects viewed the stimuli through the eye piece of the tachistoscope. At the beginning of the experimental session a mean motor response time was obtained by asking subjects to press a response key as soon as they saw a visually presented "X" for ten trials. Presentation of the stimulus activated the Coulbourn printout counter connected to the computer. Pressing any button on the response panel terminated the presentation of the stimulus and simultaneously stopped the measurement of the motor response. Once the motor response measurement was completed, presentation of the traffic sign stimuli was begun. Presentation of the standard activated the millisecond timer of the Coulbourn R22-10 printout counter and the timer was stopped by the subject's pressing of the

center response key. Pressing either of the outside response response keys in response to the standard was recorded as an error by the computer and that stimulus pair was readministered at the end of the experimental session. Pressing the center key served as the command to the computer to simultaneously terminate the presentation of the standard and measurement of the first response time, and to initiate presentation of the matching stimuli and begin measurement of the second response time. The presentation of the matching stimuli and the measurement of the second response time was stopped by the subject's pressing either the right or the left response key. Errors were recorded by the computer and trials on which errors occurred were readministered at the end of the experimental session for a valid response time. If an error was made on the readministration, the data for that subject for that stimulus pair was missing.

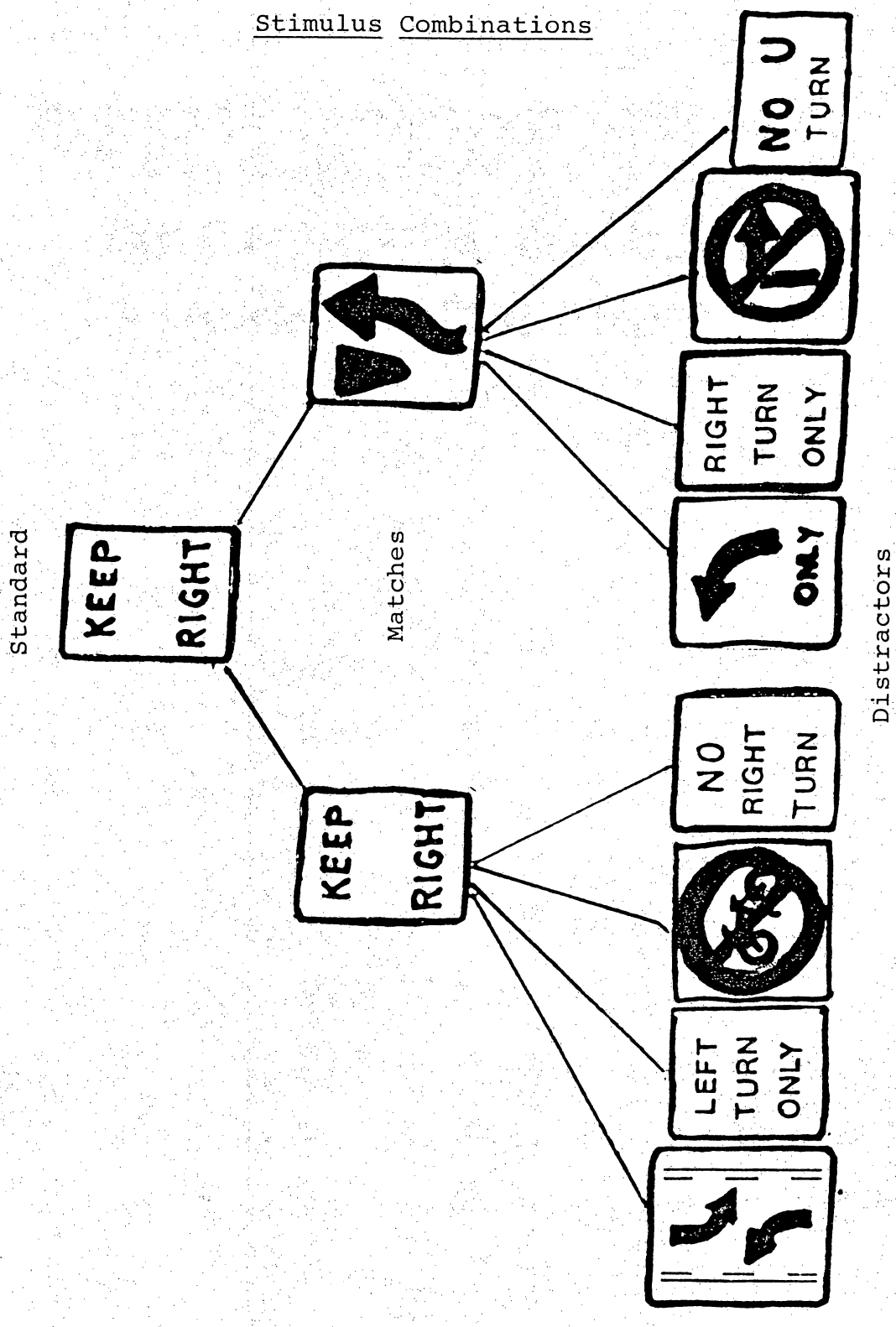
Stimuli

The stimuli were colored pictures of sixteen traffic signs taken from the 1984 Uniform Sign Chart of the State of California Department of Transportation and enlarged for use with the tachistoscope (see Appendix A for a presentation of all stimuli). The signs ranged in size from 7.5 centimeters high by 7.5 centimeters wide to 4.5 centimeters high by 6 centimeters wide, and subtended visual angles ranging from 4.45° for the largest sign to 3.56° for the

for the smallest sign. The traffic signs were divided into two categories: 1) affirmative regulatory signs; and 2) negative regulatory signs. This variable is referred to as message type. Each message type was presented in one of two forms, either verbal or symbolic. This variable is referred to as sign type. Using a matching to standard reaction time paradigm, each sign was shown eight times. On four of the trials with a given standard the match agreed with the standard on the verbal-symbolic dimension and on four of the trials the match did not agree with the standard on the verbal-symbolic dimension. Likewise, on four trials the distractor agreed with the standard on the verbal-symbolic dimension and on four trials it did not. In addition, on half of the trials with each standard the distractor agreed with the standard on the negative-affirmative dimension and on half of the trials it did not. Figure 1 provides an example for a verbal affirmative standard. As can be seen from looking at the figure, there are two possible correct matches for each standard, the verbal version of the sign or the symbolic version of the sign. In addition, there are four possible distractors which can be paired with the correct match: 1) a symbolic affirmative sign; 2) a verbal affirmative sign; 3) a symbolic negative sign; or 4) a verbal negative sign. There was an equal probability of the correct match appearing on the right or the left half of the visual field. Signs were shown in one of four pre-determined

FIGURE 1

Stimulus Combinations



random orders so that every sixth subject in each age group was shown a new order of presentation.

Procedure

Subjects were welcomed and read prepared instructions (see Appendix B). Visual acuity was assessed by asking subjects to read the 20/30 line on the Snellen Chart, which is the standard acceptable to the California Department of Motor Vehicles for driver's license applicants. A mean motor response time was obtained by asking subjects to press a response key as soon as they saw a visually presented "X" for ten trials. Before the measurement of the response times to the traffic signs was begun, each subject was shown each of the sixteen sign variations. This was done in order that subjects might become familiar with the procedure as well as to insure that they were familiar with the verbal and symbolic pairs.

The experiment consisted of 128 trials excluding the practice run. On each trial the experimenter prepared the subject by saying the word "ready" which was followed by the presentation of a traffic sign in the visual field. Each subject was instructed to press the center response key as soon as she understood the message of the presented sign. The response terminated the presentation of the stimulus and stopped the measurement of the first reaction time. A new stimulus showing a matching and a non-matching sign was

immediately presented and the measurement of the second reaction time begun. The subjects were instructed to press the button on the side of the response keyboard that corresponded to the side of the visual field on which the sign appeared whose message matched the message of the standard. All subjects were given a short rest break between the sixty-fourth and sixty-fifth stimulus pairs.

RESULTS

The error rate was 4.5% for the older subjects and 3.2% for the younger subjects and appeared to be randomly distributed across signs. The higher error rate for the older subjects was the result of several of the older women having difficulty finding the center response key and mistakenly pressing either the right or the left key for the comprehension response. In instances where an error was made, no feedback was given to the subject and the stimuli on which the error occurred were readministered at the end of the experimental session. Seven of the older subjects pressed the left or the right key for the comprehension measurement during the readministration and therefore had missing response times on those stimuli.

Mean simple reaction time was covaried with mean comprehension times for older and younger subjects for each of the thirty-two stimulus types. A significant main effect for mean simple reaction time was found ($F[1,30]=19.14$, $P<.001$, $MS[err]=.50357$). The mean simple response time for the younger women was .445 seconds, whereas the mean simple response time for the older women was .495 seconds. Because mean simple reaction time was significantly faster for younger subjects, it was used as a covariate in all

subsequent analyses. Table 1 presents the unadjusted means for all stimulus types and Table 2 presents the adjusted means for all stimulus types.

The data were next subjected to a four way analysis of variance involving the following variables: age group (young or old); response type (comprehension or match); message type (affirmative or negative); and sign type of the standard (verbal or symbolic). Again, younger subjects were faster than older subjects ($F[1,31]=65.34$, $P<.001$, $MS[err]=.44160$). In addition, match time was faster than comprehension time ($F[1,31]=52.85$. $P<.001$, $MS[err]=.32226$; responses to negative standards were faster than responses to affirmative standards ($F[1,31]=10.22$, $P<.004$, $MS[err]=.01975$); and responses to verbal standards were faster than responses to symbolic standards ($F[1,31]=24.52$, $P<.001$. $MS[err]=.02172$). Table 3 presents a summary of these results.

A significant interaction was found between response type and message type ($F[1,31]=22.49$, $P<.001$, $MS[err]=.00039$). Match times were faster than comprehension times and responses to negative standards were faster than responses to affirmative standards. The difference in response times to negatives and affirmatives was greater for the matching task than for the comprehension task (See Table 4).

There was also a significant interaction between response type and sign type ($F[1,31]=55.77$, $P<.001$, $MS[err]=.01066$). Match times were faster than comprehension times

TABLE 1

Unadjusted Mean Response Times To Stimulus Pairs

Young

	Comprehension				Match			
	Affirmative		Negative		Affirmative		Negative	
	Verbal	Symbolic	Verbal	Symbolic	Verbal	Symbolic	Verbal	Symbolic
+++[1]	3.519	3.543	3.468	3.535	2.953	2.851	2.938	2.831
-++	3.682	3.535	3.623	3.500	3.067	3.147	2.955	3.004
++-	3.311	3.552	3.598	3.437	2.870	2.814	2.880	2.819
-+-	3.459	3.604	3.549	3.632	3.010	2.979	2.919	2.961
+-+	3.524	3.497	3.638	3.496	2.928	2.878	2.953	2.771
--+	3.577	3.813	3.514	3.585	3.156	3.106	2.881	3.002
+--	3.553	3.636	3.709	3.444	2.898	2.856	2.898	2.792
---	3.639	3.613	3.497	3.579	3.100	3.202	3.050	2.939

Old

	Comprehension				Match			
	Affirmative		Negative		Affirmative		Match	
	Verbal	Symbolic	Verbal	Symbolic	Verbal	Symbolic	Verbal	Symbolic
+++	4.158	4.375	3.866	4.453	3.624	3.437	3.514	3.281
-++	4.636	4.112	4.581	4.391	3.865	3.891	3.565	3.807
++-	4.137	4.386	4.418	4.285	3.574	3.593	3.598	3.406
-+-	4.411	4.125	4.291	3.979	4.075	3.701	3.713	3.826
+-+	4.431	4.284	4.379	4.131	3.475	3.498	3.625	3.278
--+	4.233	4.549	4.334	4.373	4.171	3.998	3.772	3.905
+--	4.272	4.510	4.390	4.413	3.559	3.457	3.544	3.644
---	4.570	4.201	4.452	4.683	3.770	4.274	3.778	3.818

$F[1,30]=64.99$, $P<.001$, $MS[err]=3.56835$.

---

[1]Symbols indicate agreement of the standard with its correct match and the distractor. The first symbol indicates if the correct match agrees with the standard on the verbal-symbolic dimension. The second symbol indicates if the distractor agrees with the standard on the verbal-symbolic dimension. The third symbol indicates if the distractor agrees with the standard on the affirmative-negative dimension. (+ indicates agreement; - indicates disagreement.)

TABLE 2

Adjusted Mean Response Times To Stimulus Pairs

Young

	Comprehension				Match			
	Affirmative		Negative		Affirmative		Negative	
	Verbal	Symbolic	Verbal	Symbolic	Verbal	Symbolic	Verbal	Symbolic
+++[1]	3.546	3.570	3.495	3.562	2.980	2.878	2.965	2.858
-++	3.710	3.562	3.650	3.527	3.094	3.174	2.983	3.031
++-	3.338	3.631	3.625	3.659	2.897	3.006	2.907	2.988
-+-	3.486	3.579	3.577	3.465	3.037	2.841	2.946	2.846
+-+	3.551	3.524	3.665	3.523	2.956	2.905	2.984	2.798
--+	3.604	3.841	3.541	3.612	3.183	3.133	2.908	3.029
+--	3.583	3.663	3.736	3.471	2.926	2.884	2.925	2.819
---	3.667	3.640	3.524	3.607	3.127	3.229	3.077	2.966

Mean Simple Reaction Time=.445 seconds.

Old

	Comprehension				Match			
	Affirmative		Negative		Affirmative		Negative	
	Verbal	Symbolic	Verbal	Symbolic	Verbal	Symbolic	Verbal	Symbolic
+++	4.117	4.334	3.824	4.411	3.582	3.396	3.472	3.329
-++	4.594	4.070	4.539	4.349	3.823	3.850	3.523	3.766
++-	4.095	4.084	4.376	3.937	3.532	3.659	3.556	3.784
-+-	4.369	4.345	4.250	4.244	4.033	3.551	3.671	3.365
+-+	4.389	4.242	4.337	4.089	3.433	3.456	3.583	3.237
--+	4.192	4.507	4.292	4.331	4.129	3.956	3.730	3.863
+--	4.230	4.468	4.348	4.371	3.517	3.415	3.503	3.602
---	4.528	4.159	4.410	4.641	3.728	4.232	3.736	3.776

Mean Simple Reaction Time =.495, ($F[1,30]=19.14$, $P<.001$, $MS[err]=3.56835$)

---

[1]Symbols indicate agreement of the standard with its correct match and the distractor. The first symbol indicates if the correct match agrees with the standard on the verbal-symbolic dimension. The second symbol indicates if the distractor agrees with the standard on the verbal-symbolic dimension. The third symbol indicates if the distractor agrees with the standard on the affirmative-negative dimension. (+ indicates agreement; - indicates disagreement.)

TABLE 3

Adjusted Mean Response Times for Response Type, Message Type, and Sign Type of the Standard

	Comprehension				Match			
	Affirmative		Negative		Affirmative		Negative	
	Verbal	Symbolic	Verbal	Symbolic	Verbal	Symbolic	Verbal	Symbolic
Young	3.560	3.626	3.601	3.553	3.025	3.006	2.961	3.360
Old	4.315	4.276	4.297	4.297	4.722	3.690	3.597	4.006

TABLE 4

Two-Way Interaction of Response Type With Message Type

	Comprehension	Match
Affirm	$\bar{X}$=3.944 S.D.=.352	$\bar{X}$=3.611 S.D.=.698
Neg	$\bar{X}$=3.937 S.D.=.360	$\bar{X}$=3.481 S.D.=.379

$F[1,31]=22.49$, $P < .001$, $MS[err]=.00039$

and responses to symbolic standards were faster than responses to verbal standards. The difference in response times to verbal and symbolic stimuli was greater on the matching task than on the comprehension task (See Table 5).

A significant interaction also occurred between message type and sign type ($F[1,31]=37.26$, $P<.001$, $MS[err]=.01618$). Response times to verbal negatives were faster than to verbal affirmatives, whereas response times to symbolic affirmatives were faster than to symbolic negatives (See Table 6).

A significant three way interaction occurred among response type, message type and sign type ($F[1,31]=98.77$, $P<.001$, $MS[err]=.00873$). For the comprehension task, responses to verbal affirmatives were faster than to verbal negatives, but responses to symbolic negatives were faster than to symbolic affirmatives. For the matching task, response times to verbal negatives were faster than response times to verbal affirmatives, but response times to symbolic affirmatives were faster than to symbolic negatives (See Table 7).

The next analysis of variance was performed to determine whether a match was easier to make if the matching stimulus agreed with the standard on the verbal-symbolic dimension, or if it was easier when the match did not agree with the standard on this dimension. The analysis involved the following variables: age group; message type; and agreement

TABLE 5

Two-Way Interaction of Response Type With Sign Type

	Comprehension	Match
Verbal	$\bar{X}$=3.943 S.D.=.363	$\bar{X}$=3.576 S.D.=.706
Symbol	$\bar{X}$=3.938 S.D.=.350	$\bar{X}$=3.516 S.D.=.372

$F[1,31]=55.77$, $P<.001$, $MS[err]=.01066$

TABLE 6

Two-Way Interaction of Message Type With Sign Type

	Affirmative	Negative
Verbal	$\bar{X}$=3.905 S.D.=.363	$\bar{X}$=3.614 S.D.=.473
Symbol	$\bar{X}$=3.650 S.D.= .450	$\bar{X}$=3.804 S.D.=.369

$F[1,31]=37.26$, $P<.001$, $MS[err]=.01618$

TABLE 7

Three-Way Interaction of Response Type With Message Type And Sign Type

Comprehension

	Affirmative	Negative
Verbal	$\bar{X}$=3.937 S.D.=.377	$\bar{X}$=3.949 S.D.=.372
Symbol	$\bar{X}$=3.951 S.D.=.325	$\bar{X}$=3.925 S.D.=.372

Match

	Affirmative	Negative
Verbal	$\bar{X}$=3.874 S.D.=.849	$\bar{X}$=3.279 S.D.=.318
Symbol	$\bar{X}$=3.348 S.D.=.342	$\bar{X}$=3.683 S.D.=.323

$F[1,31]=98.77$, $P<.001$, $MS[err]=.00873$

of the match with the standard on the verbal-symbolic dimension (same or different). A significant main effect was found for age ($F[1,31]=78.59$, $P<.001$, $MS[err]=.38610$). The mean response time for the younger women was 2.963 seconds and the mean response time for the older women was 3.669 seconds. A significant main effect was also found for message type ($F[1,31]=36.95$, $P<.001$, $MS[err]=.01610$). The mean response time to negative stimuli was 3.267 seconds and the mean response time to affirmative stimuli was 3.365 seconds. In addition, a significant main effect occurred for agreement of the match with the standard ($F[1,31]=73.00$, $P<.001$, $MS[err]=.05905$). The mean response time when the match and standard agreed on the verbal-symbolic dimension was 3.185 seconds, whereas the mean response time when the match and standard differed on the verbal-symbolic dimension was 3.447 seconds.

A significant interaction was found between message type and agreement of the match with the standard ($F[1,31]=10.94$, $P<.003$, $MS[err]=.02529$). Match times were slower if the match and standard differed on the verbal-symbolic dimension. However, different matches caused a greater increase in response times for affirmative standards than for negative standards (See Table 8).

There was also a significant interaction between sign type and agreement of the match with the standard ($F[1,31]=10.24$, $P<.003$, $MS[err]=.03287$). As in Table 8, match times

TABLE 8

Two-Way Interaction of Message Type and Agreement of the Standard and Match as to Sign Type

	Affirmative	Negative
Same	$\bar{X}$=3.201 S.D.=.308	$\bar{X}$=3.170 S.D.=.305
Diff	$\bar{X}$=3.528 S.D.=.420	$\bar{X}$=3.365 S.D.=.391

$F[1,31]=10.94$, $P<.003$, $MS[err]=.02529$

were slower if the match and standard differed on the verbal-symbolic dimension. However, different matches caused a greater increase in reaction time if the standard were symbolic than if the standard were verbal (See Table 9).

A significant interaction also occurred between age and agreement of the match with the standard ($\underline{F}[1,31]=10.94$, $P \leq .003$, $\underline{MS}[err]=.02529$). Matches were more difficult for older subjects when match and standard were in different verbal-symbolic dimensions than they were for younger subjects (See Table 10).

A significant three-way interaction was found among message type, sign type, and agreement of the match with the standard ($\underline{F}[1,31]=4.86$, $P < .035$, $\underline{MS}[err]=.01757$). See Table 11.

The final analysis of variance was performed to investigate the role of the distractor and involved the variables of age, message type, sign type, and degrees of difference between the distractor and the standard (no difference, differ only on the affirmative-negative dimension, differ only on the verbal-symbolic dimension, or differ on both the affirmative-negative and the symbolic-verbal dimensions). Only main effects for age ($\underline{F}[1,37]=76.04$, $P < .001$, $\underline{MS}[err]=1.07014$) and message type ($\underline{F}[1,38]=28.71$, $p < .001$, $\underline{MS}[err]=.04998$) were significant. The mean response time for older subjects was 3.709 seconds and the mean response time for younger subjects was 2.985 seconds.

TABLE 9

Two-Way Interaction of Sign Type and Agreement of the Standard and Match as to Sign Type

	Verbal	Symbolic
Same	$\bar{X}$=3.236 S.D.=.308	$\bar{X}$=3.134 S.D.=.297
Diff	$\bar{X}$=3.424 S.D.=.408	$\bar{X}$=3.469 S.D.=.419

$F[1,31]=10.24$, $P < .004$, $MS[err]=.03287$

TABLE 10

Two-Way Interaction of Age with Agreement of the Standard and Match as to Sign Type

	Young	Old
Same	$\bar{X}$=2.884 S.D.=.047	$\bar{X}$=3.487 S.D.=.066
Diff	$\bar{X}$=3.043 S.D.=.067	$\bar{X}$=3.851 S.D.=.108

$F[1,31]=10.94$, $P < .003$, $MS[err]=.02529$

TABLE 11

Three-Way Interaction of Message Type with Sign Type and Agreement of the Standard and Match as to Sign Type

Affirmative

	Verbal	Symbolic
Same	$\bar{X}$=3.232 S.D.=.306	$\bar{X}$=3.170 S.D.=.307
Diff	$\bar{X}$=3.523 S.D.=.365	$\bar{X}$=3.534 S.D.=.413

Negative

	Verbal	Symbolic
Same	$\bar{X}$=3.240 S.D.=.313	$\bar{X}$=3.099 S.D.=.283
Diff	$\bar{X}$=3.326 S.D.=.362	$\bar{X}$=3.404 S.D.=.417

$F[1,31]=4.86$, $P < .035$, $MS[err]=.01757$

Responses to negatives ($\bar{X}$=3.297 seconds) were faster than responses to affirmatives ($\bar{X}$=3.392 seconds). No significant interactions were found, but the interactions between sign type and degrees of difference between the standard and the distractor ($F[3,114]=2.19$, $P<.09$, $MS[err]=.04829$) and among sign type, degrees of difference and age ($F[3,114]=2.39$, $P<.07$, $MS[err]=.04892$) approached significance. Matches were faster to symbolic than to verbal standards. Older subjects had faster response times when distractors and standards differed on both or no dimensions, whereas younger subjects made faster matches if the standard and distractor differed on the affirmative-negative or the verbal-symbolic dimensions.

DISCUSSION

Simple Reaction Time

Older subjects in this study had slower simple reaction times than did younger subjects. Previous reasearch (e.g. Cerella, Poon, & Williams, 1980; Gottsdanker, 1982) has demonstrated a statistically significant but minimal lengthening of simple response time with age. When simple reaction time was covaried with comprehension time and match time for both younger and older subjects in this study, older subjects' responses were slower than those of younger subjects even after the adjustment for speed of responding. This finding was not unexpected in light of the relative complexity of the matching task and the usual finding that response times increase more for older subjects than for younger subjects as the task increases in complexity. That older subjects were significantly slower than younger subjects even when simple motor response time was controlled is consistent with the findings of Cerella, Poon, and Williams (1980) that more complex tasks result in greater performance deficits for the elderly. Cerella's et al. examination of their data revealed a slight slowing in sensorimotor tasks and a more severe slowing on tasks involving mental transformations. In the present study, mean simple response

time for younger and older subjects differed by only .05 seconds, but differences of up to one second occurred for the comprehension and matching tasks.

Comprehension Times

In general, comprehension times were slower for older subjects in this study than for younger subjects, but the patterns of responding were the same for both age groups. Both older and younger subjects responded more quickly to verbal than to symbolic standards. These findings agree with those of Mergler and Zandi (1983) but do not agree with those of Halpern (1984). Halpern (1984) found no difference in the response times of younger subjects to verbal or symbolic signs, but found that older subjects responded an average of .2 seconds more quickly to verbal than to symbolic signs. There were methodological differences between the present study and that of Halpern (1984) which may account for the difference in the findings. The present study examined only the responses of women, whereas Halpern's (1984) study had equal numbers of male and female subjects. That males have better spatial abilities than females is well documented (Halpern, 1986). It may well be that the greater spatial abilities of the younger males in Halpern's (1984) study obscured the differences in response time to verbal or symbolic signs for the younger subjects. In addition, in Halpern's (1984) study, the experimenter read

aloud a traffic sign message and subjects were asked to respond with a verbal "Yes" or "No" if the message read to them matched or did not match the message of a sign projected on a viewing screen. Since the referent message was presented in verbal form, the greater response latency for older subjects may simply reflect a greater difficulty in matching symbolic signs to a verbal representation in memory.

Responses to negative standards were faster than to affirmative standards. It appears from the data that the negation in a traffic sign message makes that sign easier to comprehend for both younger and older women. This finding lends support to the findings of Ells and Dewar (1979) that warning signs take less time to comprehend than regulatory signs. In Ells and Dewar's (1979) study, 75% of the regulatory signs sampled contained a negative, whereas all warning signs sampled were affirmative. The data from the present study indicate that it was not the negation that made regulatory signs in Ells and Dewar's (1979) study more difficult to comprehend than warning signs. As there are also shape and color differences between warning and regulatory signs, more research is needed to determine what aspect of warning signs gives them their advantage over regulatory signs.

Match Times

Overall, match times were faster than comprehension

times for both older and younger subjects. Because the matching task is a test of recognition memory, the meaning of the standard is activated in memory when it is presented and the subject must simply compare the two matching stimuli to the representation in memory to find the correct match. Thus, the matching response requires fewer mental operations, and therefore less time, than does the comprehension task.

For both age groups, matches to verbal standards were easier to make than matches to symbolic standards. In addition, matches to both verbal and symbolic standards were easier if the standard and match were in the same verbal-symbolic dimension. Symbolic matches to a verbal standard were more difficult than verbal matches to a symbolic standard, suggesting that women in both age groups translate a symbolic representation into its verbal form. This finding disagrees with the suggestion by Mergler and Zandi (1983) that verbal stimuli activate pictorial images even before being systematically processed but pictorial information cannot be labeled (or compared to other incoming information) until it is completely processed. In fact, the data from this study indicate that the processing of symbolic information involves translating it to a verbal code.

There were methodological differences between Mergler and Zandi's (1983) study and the present study which may account for the difference in the findings. Mergler and

Zandi (1983) presented their stimuli in counterbalanced blocks of verbal and symbolic standards. In verbal standard blocks, both match and distractor were symbolic and in symbolic standard blocks both match and distractor were verbal. Mergler and Zandi (1983) based their conclusion on the finding that subjects in both age groups had shorter response latency to verbal standard blocks than to symbolic standard blocks. Presenting stimuli in verbal standard or symbolic standard blocks may have obscured the real differences in the processing of verbal and symbolic information.

For both age groups, response times to negative signs were faster than response times to affirmative standards. This finding is surprising in view of the well documented findings of greater difficulty in processing negative information (e.g., Akiyama, Brewer & Shoben, 1979; Clark & Chase, 1972; Matlin, 1983). The previous research, however, has concerned itself with the verification of statements (Clark & Chase, 1972) or with answering yes-no questions (Akiyama, Brewer, & Shoben, 1979). In both of these operations, sentences are represented in memory as propositions, such as "Star above plus" or "Robin, bird," and the propositions are then compared to a "truth index" or to general knowledge stored in memory. Traffic sign messages, however, are so brief that they may be regarded as already being in propositional form and as not requiring the

transformation needed by sentences and questions. In the case of traffic sign messages, the saliency of the negation allows it to be used as a short-cut in processing the sign's message, rather than adding another processing step as it does in the processing of statements and questions. That affirmative matches were more difficult to make when the match and standard did not agree on the verbal-symbolic dimension than were negative matches lends further support to the suggestion that, for traffic sign messages, the negation aids in processing rather than adding a processing step.

Matches to verbal negative standards were faster than to verbal affirmative standards, but matches to symbolic affirmative standards were faster than to symbolic negative standards. Three of the affirmative standards contained a directional message, but only one negative standard contained a directional message (See Appendix A). Because there was an equal probability of a correct match appearing in either the right or left half or the visual field, there was also an equal probability of the correct match appearing on the side of the visual field opposite to the directional message carried by the sign. It may be that a verbal directional message produces a stronger association with the direction than does a symbolic representation of the direction. If this is so, then it would account for the interaction between message type and sign type. Self reports from several

subjects of difficulty pressing the left response key, for example, when the sign's message said "right," suggests that this may indeed be the case.

Matches were more difficult for the older subjects if the match and standard did not agree on the verbal-symbolic dimension than they were for younger subjects. Because making a match to a standard in a different verbal-symbolic dimension involves a transformation from one form of representation to another, it is a more complex task than is making a match to a standard in the same verbal-symbolic dimension. It is this greater complexity that causes the increase in response time for older subjects.

Summary

This study attempted to answer some questions about the relative effectiveness of verbal and symbolic, affirmative and negative traffic signs in conveying their intended message to both older and younger drivers, as well as to investigate the ways in which people in different age groups process verbal and symbolic, negative and affirmative information.

For both age groups, verbal signs produced faster response times than did symbolic signs. There are at least two possible explanations for this finding. The first explanation is that women in both age groups rely on a verbal code for processing information. The additional processing

step needed to transform a symbolic representation to its verbal form would thus add to the necessary processing time. Symbolic signs would therefore be a less efficient means of conveying information to people when speed and accuracy are important goals (such as during driving).

The second explanation is that the symbolic traffic signs presently in use may not be the versions of the signs that best convey their intended message. If there is a lack of clarity in the symbolic message, this would also add to processing time and therefore make symbolic signs less efficient than their verbal counterparts. Research is needed that compares symbolic versions of traffic signs currently in use with other possible symbolic representations of the same message to determine if there are different versions of the signs which more clearly convey the intended message. Despite the increasing need to convey important information to people in a manner that is independent of their language and culture, at least where driving safety is concerned, it seems essential that we find a means of doing so that does not sacrifice the speed and accuracy with which people perceive the information.

A question remains as to whether a verbal or a symbolic sign is more effective in quickly and efficiently conveying negative information. For the comprehension task symbolic negatives produced faster response tiems, but for the

matching task, verbal negatives produced the fastest response times.

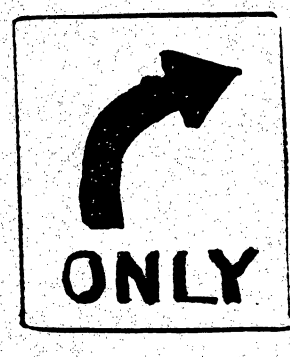
Another question raised by the findings of the present study is how people process verbal and symbolic directional information. The present study did not directly address this question, but the self-reports from subjects of greater difficulty in pressing the response key opposite to the directional message in verbal signs makes this an interesting question for future research.

The finding of an age difference in response times to verbal and symbolic information in Halpern's (1984) study which included males, and the finding of no such difference in the present study which examined only female's responses, suggests that more research is needed on gender differences in cognitive abilities in the elderly. It seems at least possible from the discrepant findings of Halpern's (1984) study and the present one that the differential rate of decline in verbal and spatial abilities may result in males and females becoming more similar in their cognitive abilities with increasing age. This, too, is an area that certainly merits further exploration.

APPENDIX A

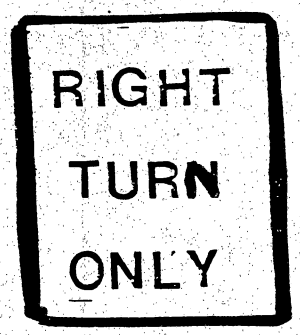
Stimulus Pairs

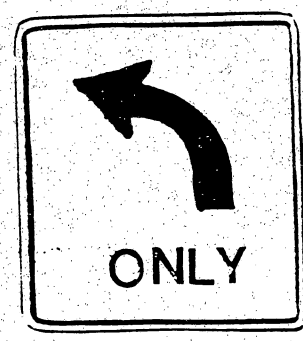
Right Turn Only (symbolic)

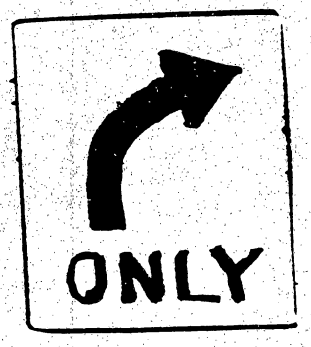


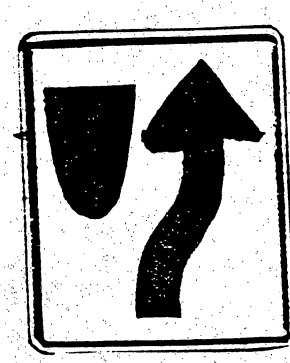
Standard

Matches and Distractors



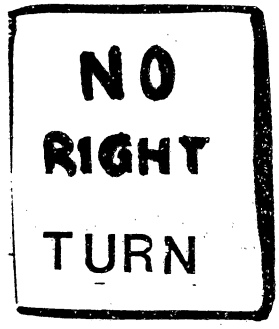


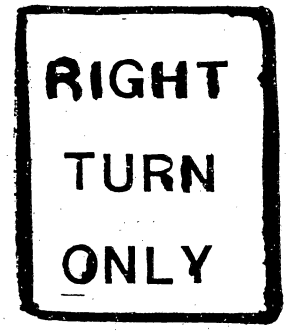


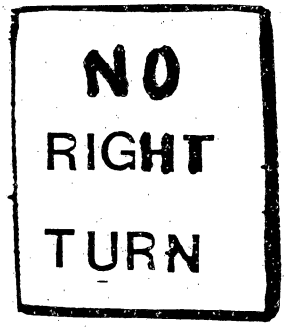


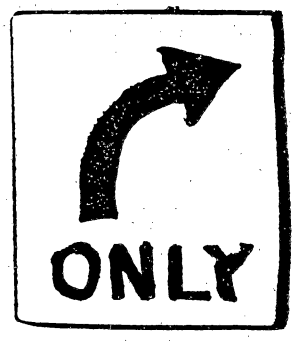
APPENDIX A (continued)

Matches & Distractors for Symbolic Right Turn Only Standard



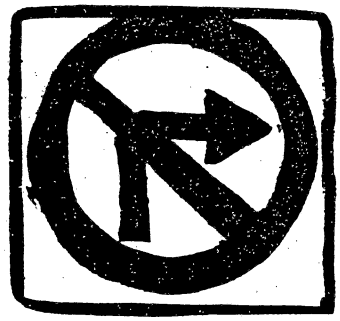


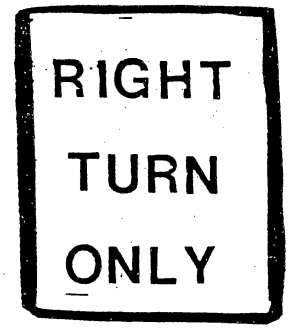


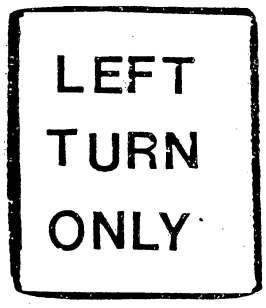


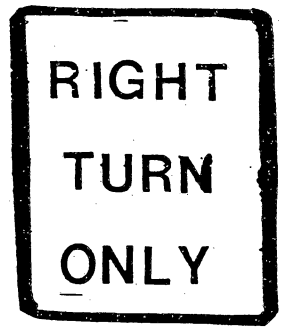
APPENDIX A (continued)

Symbolic Right Turn Only standard -- matches and distractors



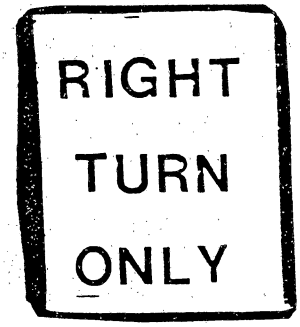






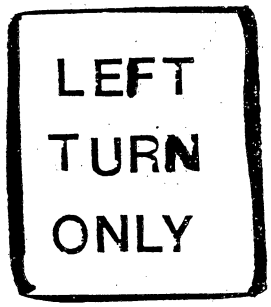
APPENDIX A (continued)

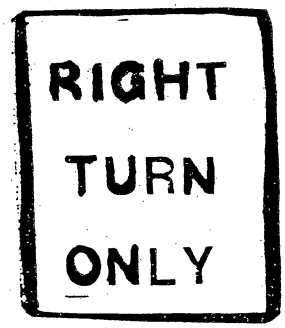
Right Turn Only (verbal)



Standard

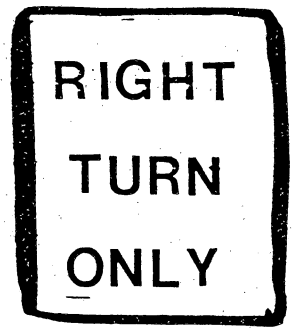
Matches and Distractors

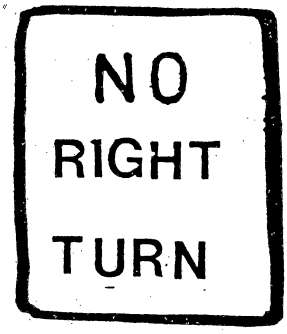


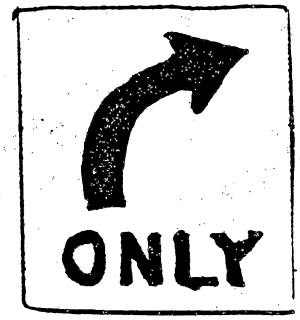


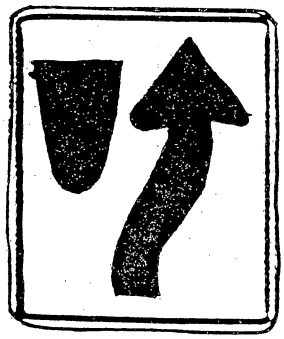
APPENDIX A (continued)

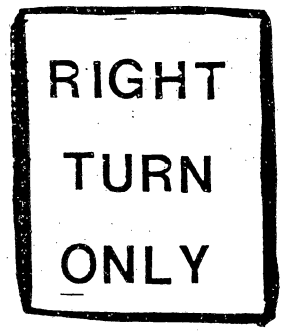
Matches & Distractors for Verbal Right Turn Only Standard





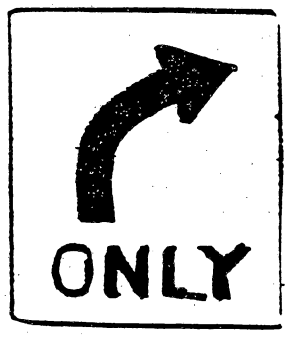


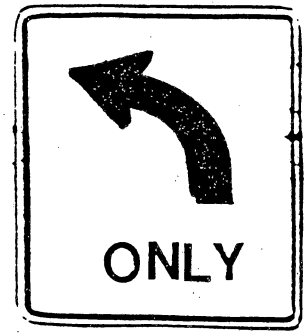


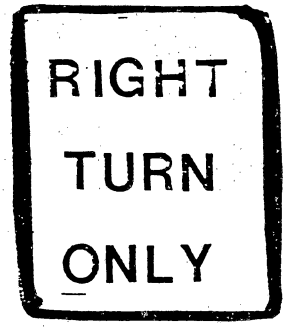


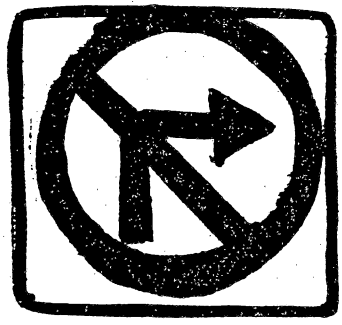
APPENDIX A (continued)

Matches & Distractors for Verbal Right Turn Only Standard



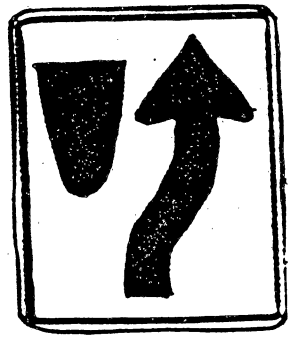






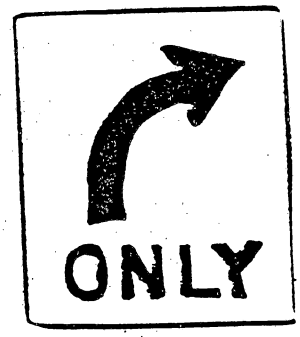
APPENDIX A (continued)

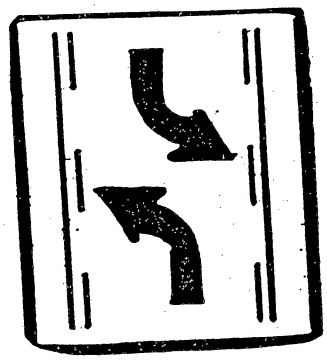
Keep Right (symbolic)

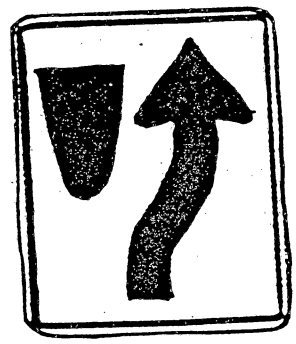


Standard

Matches and Distractors

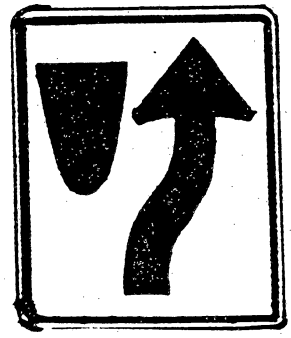


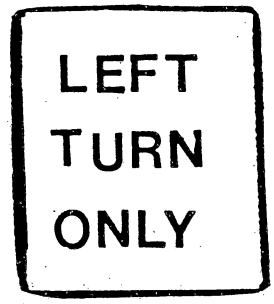




APPENDIX A (continued)

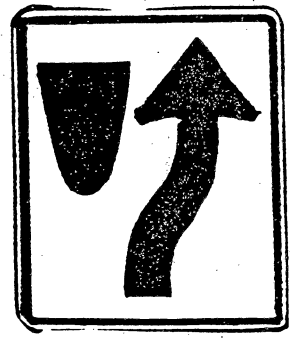
Matches & Distractors for Symbolic Keep Right Standard

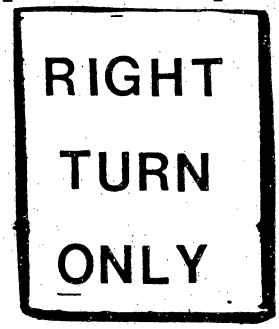


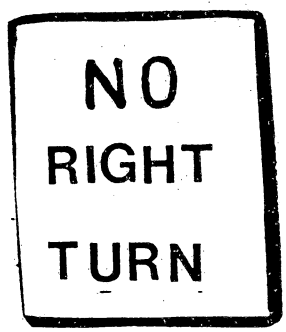


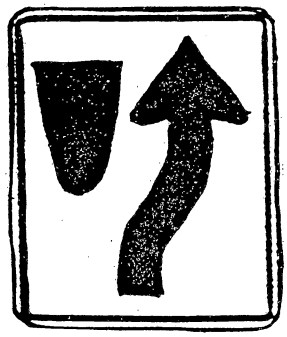
APPENDIX A (continued)

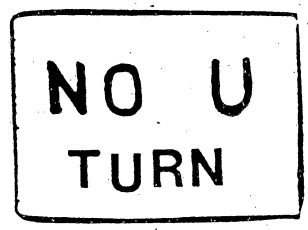
Matches & Distractors for Symbolic Keep Right Standard









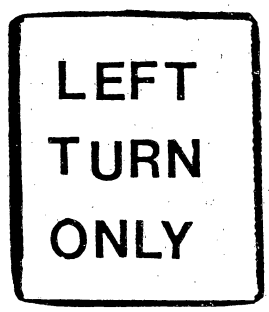


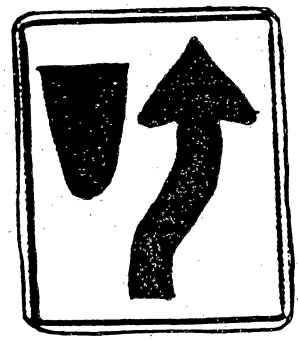
APPENDIX A (continued)

Keep Right (verbal)

Standard

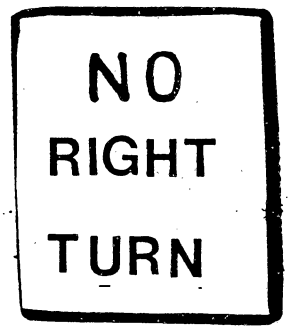
Matches and Distractors

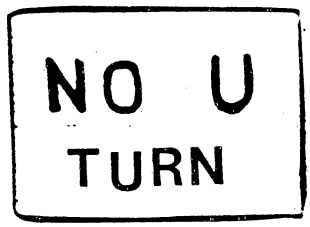


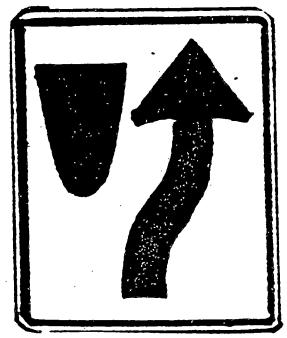


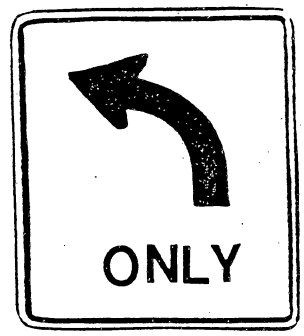
APPENDIX A (continued)

Matches & Distractors for Verbal Keep Right Standard



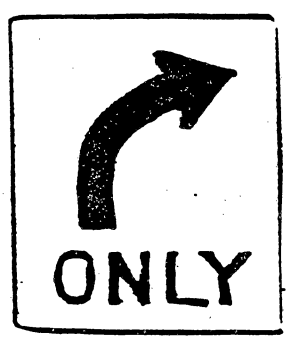


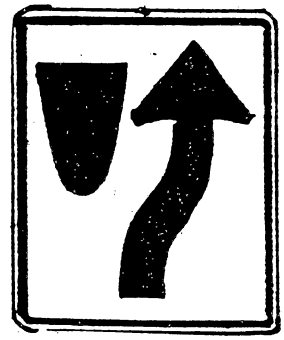


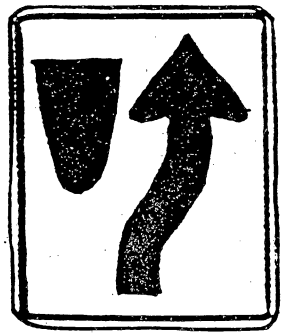


APPENDIX A (continued)

Matches and Distractors for Verbal Keep Right Standard

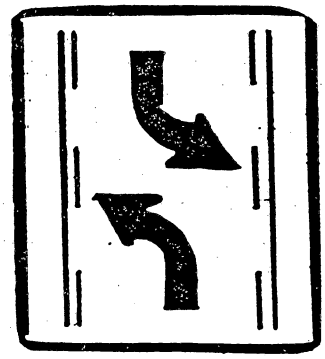






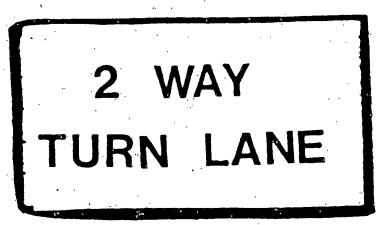
APPENDIX A (continued)

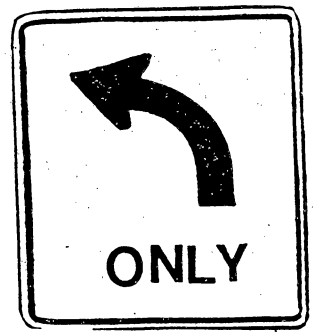
2 Way Turn Lane (symbolic)

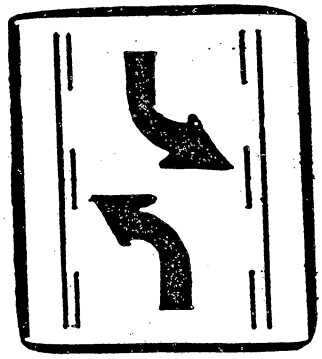


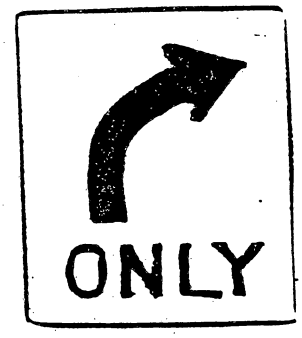
Standard

Matches and Distractors





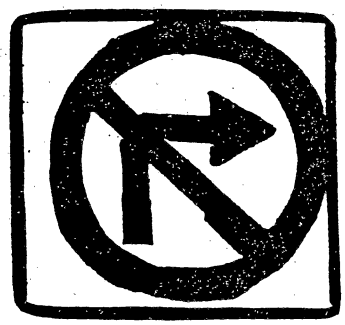


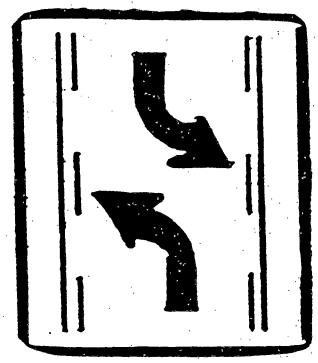


APPENDIX A (continued)

Matches & Distractors for Symbolic 2 Way Turn Lane Standard

2 WAY
TURN LANE



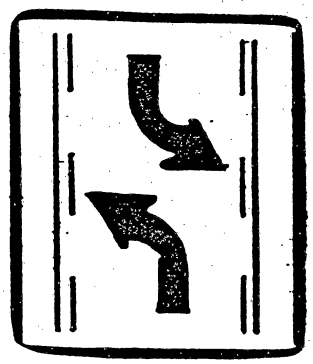


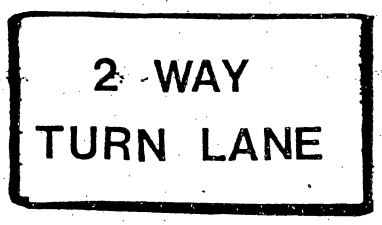
RIGHT
TURN
ONLY

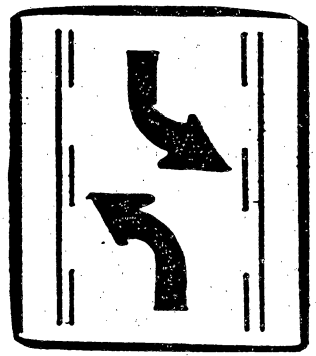
2 WAY
TURN LANE

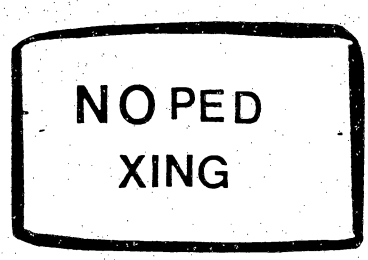
APPENDIX A (continued)

Matches & Distractors for Symbolic 2 Way Turn Lane Standard







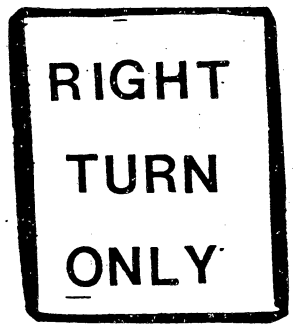


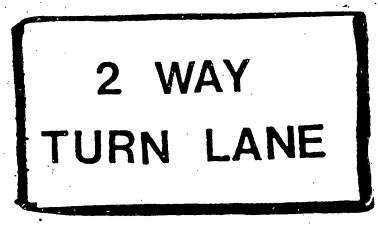
APPENDIX A (continued)

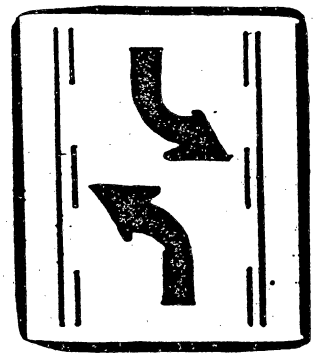
2 Way Turn Lane (verbal)

Standard

Matches and Distractors

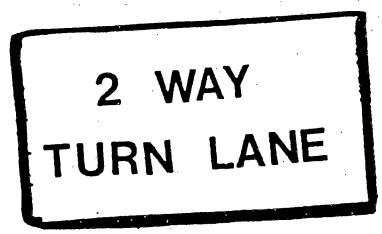


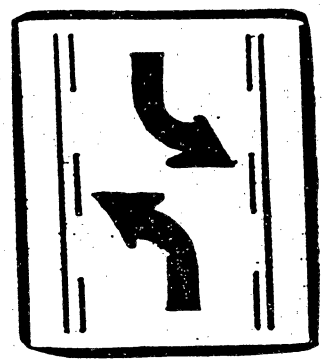


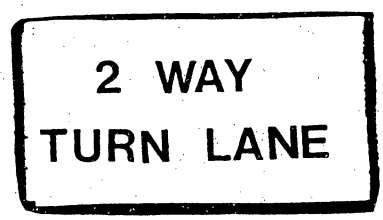


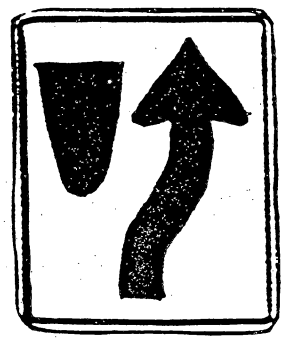
APPENDIX A (continued)

Matches & Distractors for Verbal 2 Way Turn Lane Standard



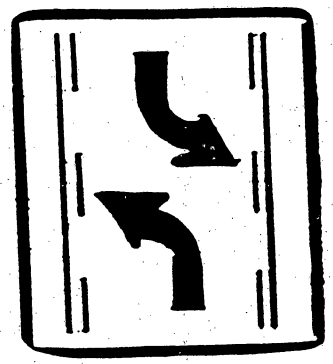


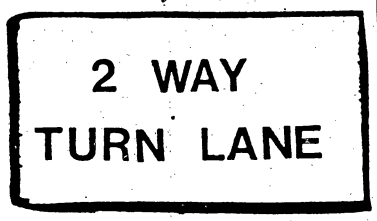


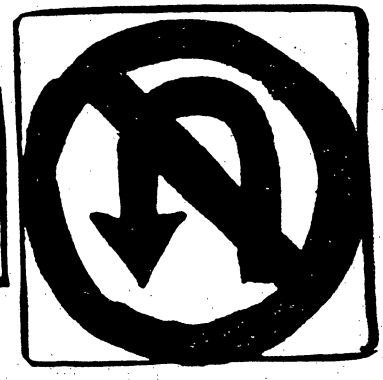


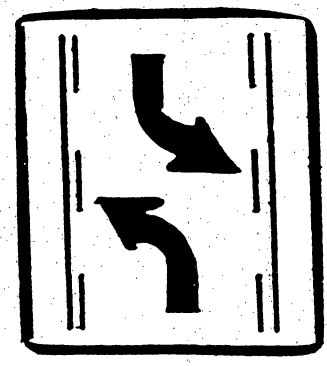
APPENDIX A (continued)

Matches & Distractors for Verbal 2 Way Turn Lane Standard



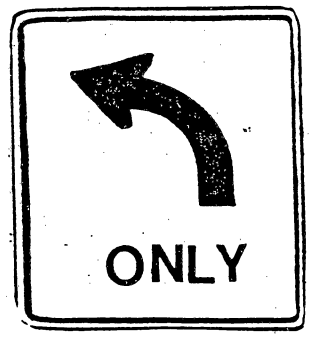






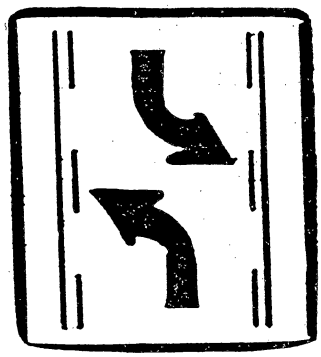
APPENDIX A (continued)

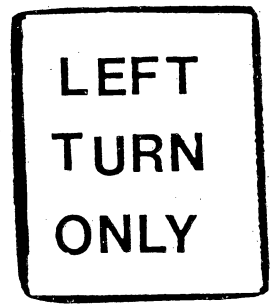
Left Turn Only (symbolic)

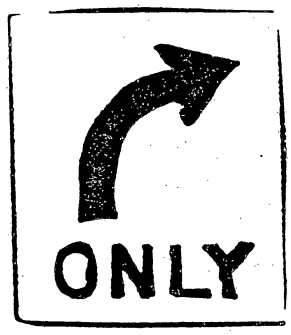


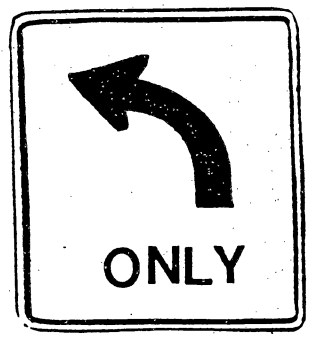
Standard

Matches and Distractors



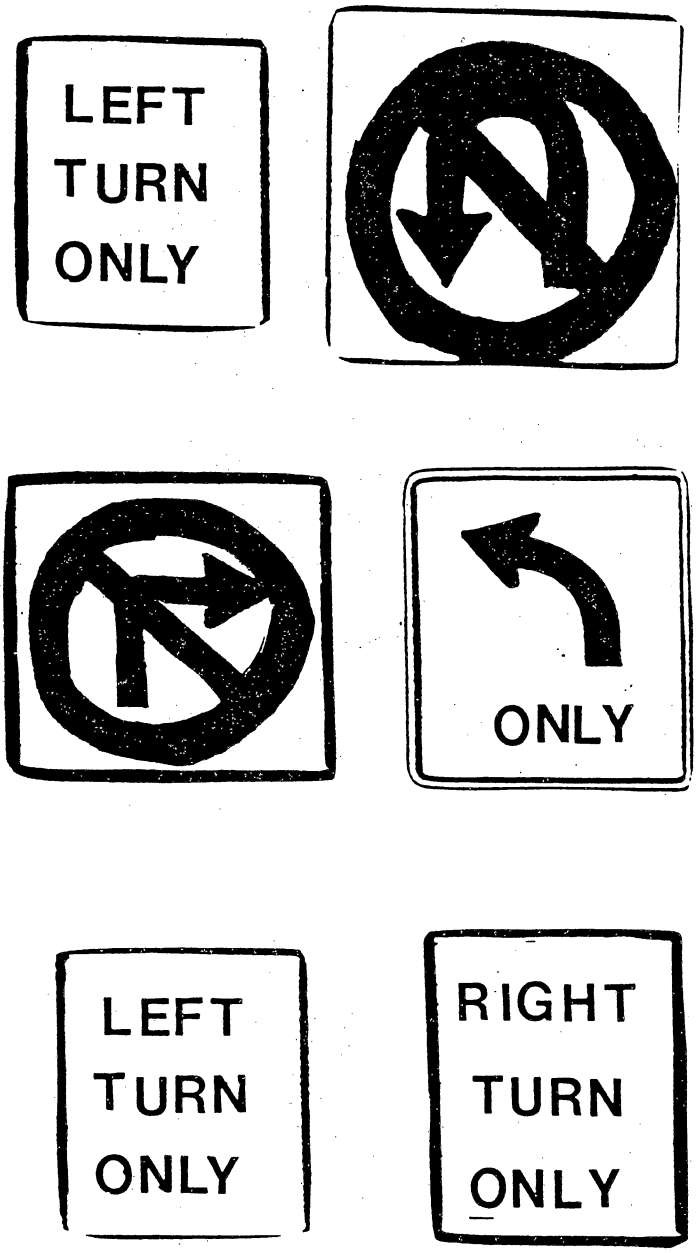






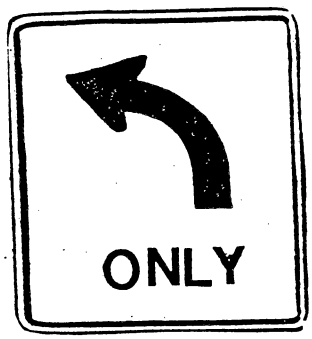
APPENDIX A (continued)

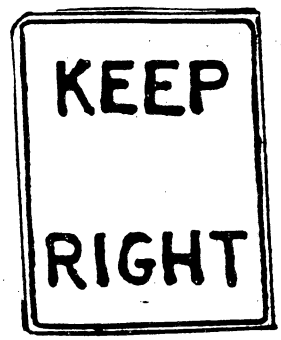
Matches & Distractors for Symbolic Left Turn Only Standard

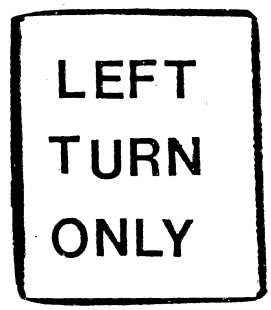


APPENDIX A (continued)

Matches & Distractors for Symbolic Left Turn Only Standard

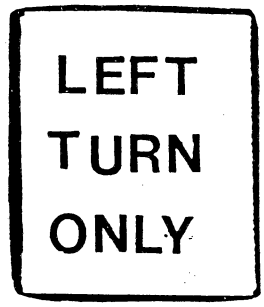






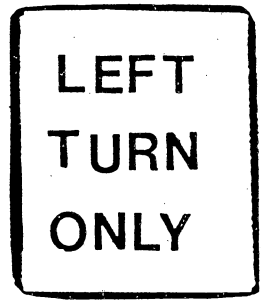
APPENDIX A (continued)

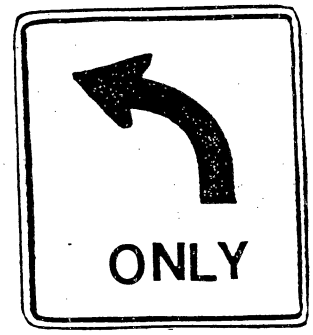
Left Turn Only (verbal)



Standard

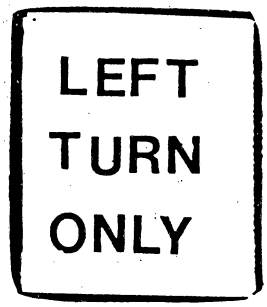
Matches and Distractors

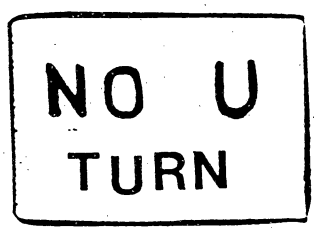


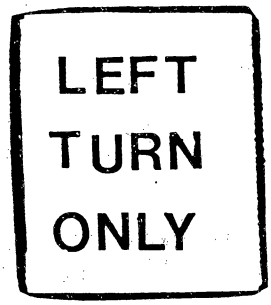


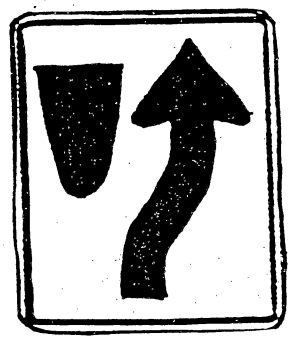
APPENDIX A (continued)

Matches & Distractors for Verbal Left Turn Only Standard



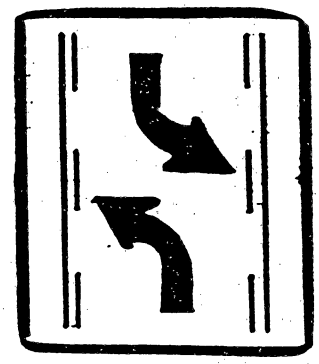


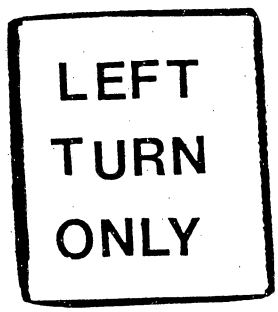


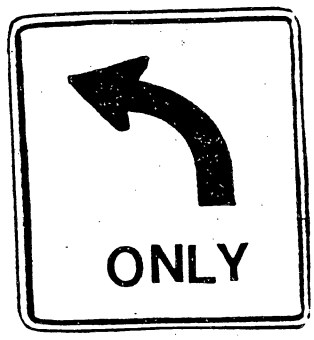


APPENDIX A (continued)

Matches & Distractors for Verbal Left Turn Only Standard





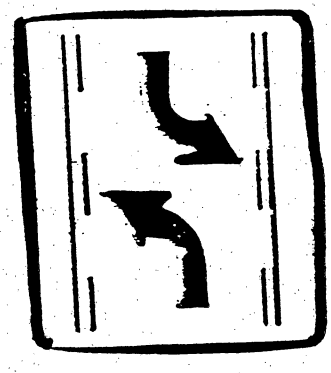


APPENDIX A (continued)

No Bicycles (symbolic)

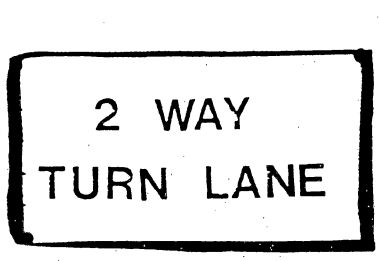
Standard

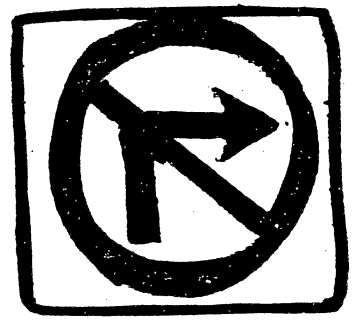
Matches and Distractors

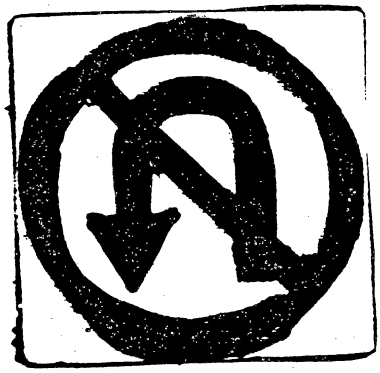


APPENDIX A (continued)

Matches & Distractors for Symbolic No Bicycles Standard

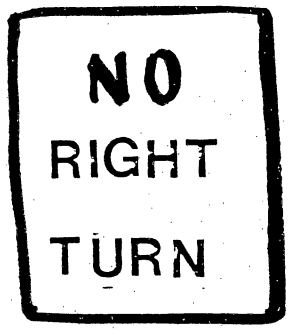


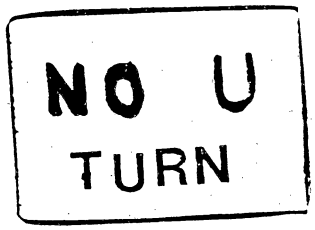


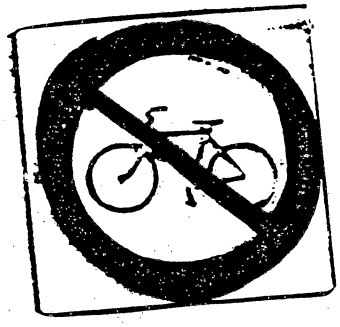


APPENDIX A (continued)

Matches & Distractors for Symbolic No Bicycles Standard

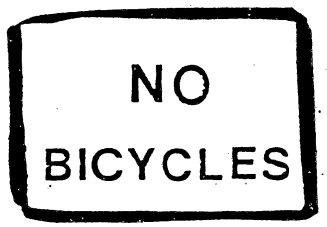






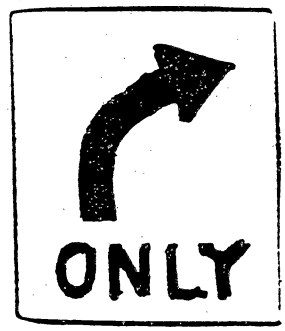
APPENDIX A (continued)

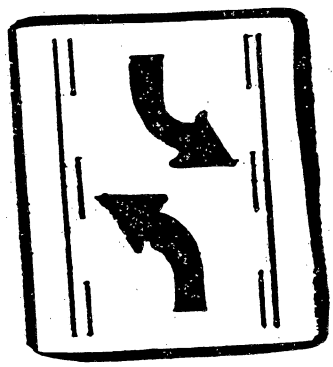
No Bicycles (verbal)



Standard

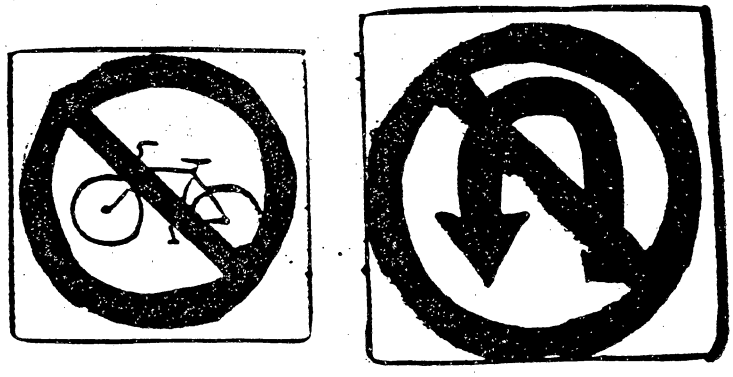
Matches and Distractors

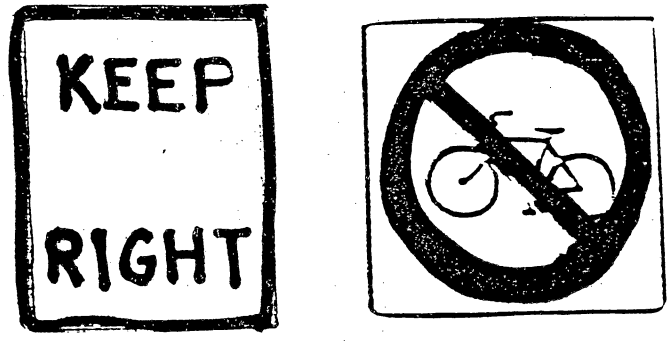




APPENDIX A (continued)

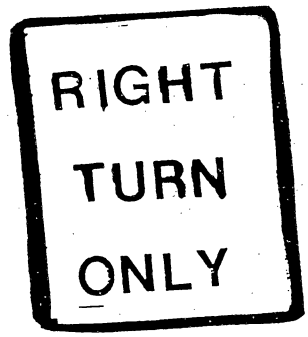
Matches and Distractors for Verbal No Bicycles Standard

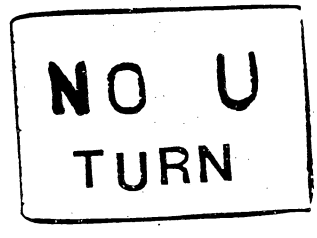




Appendix A (continued)

Matches and Distractors for Verbal No Bicycles Standard

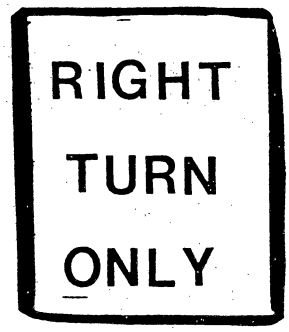


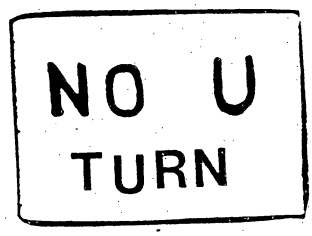


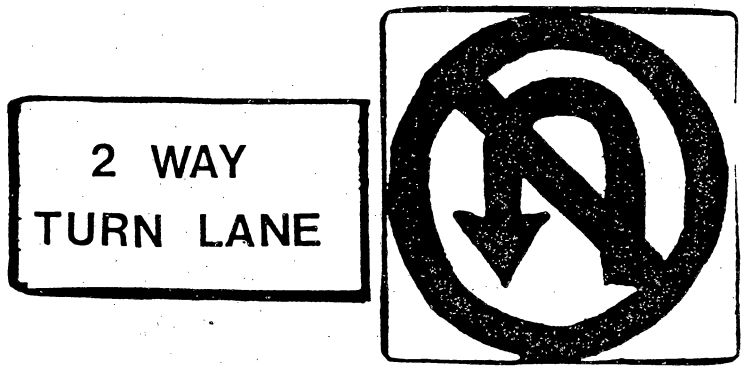
No U Turn (symbolic)

Standard

Matches and Distractors

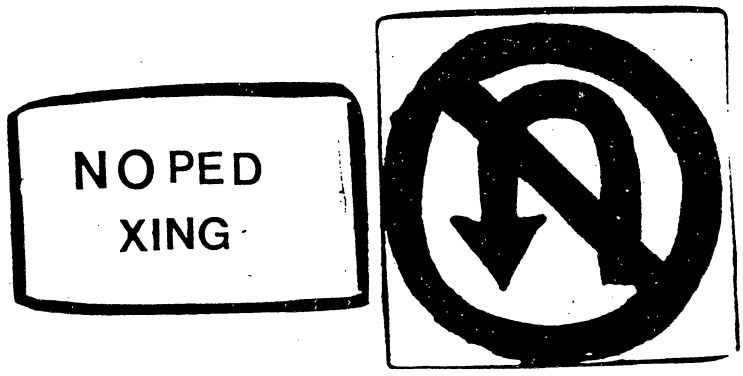


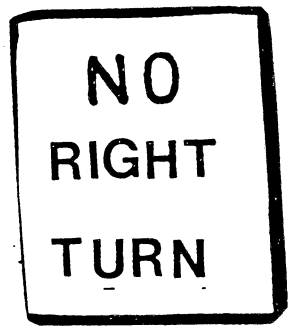


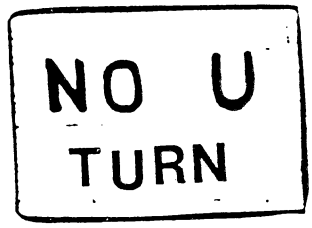


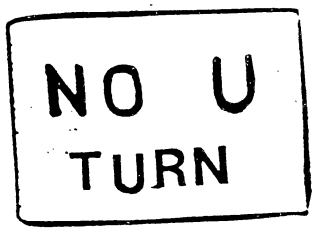
APPENDIX A (continued)

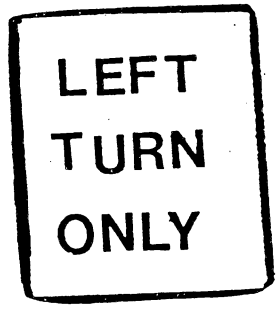
Matches & Distractors for Symbolic No U Turn Standard





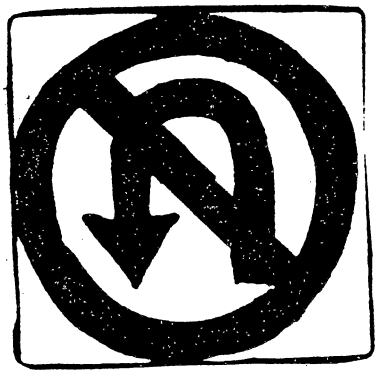




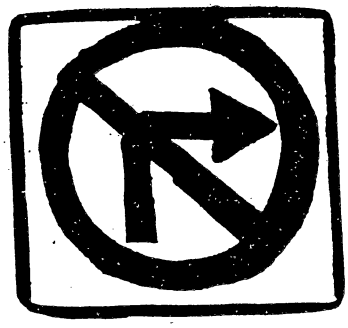


APPENDIX A (continued)

Matches & Distractors for Symbolic No U Turn Standard

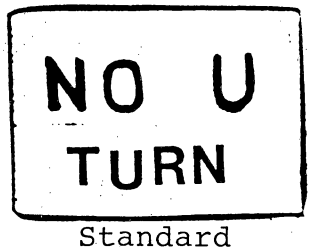


NO U
TURN



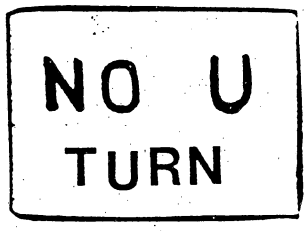
APPENDIX A (continued)

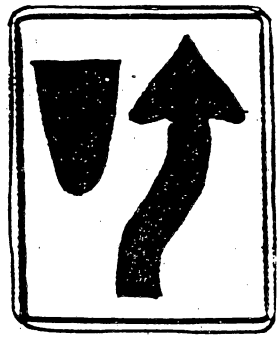
No U Turn (verbal)

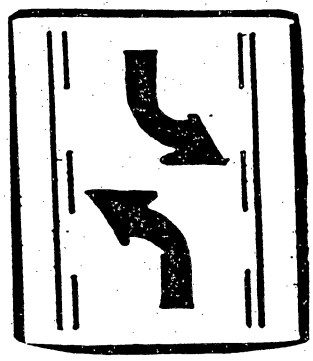


Standard

Matches and Distractors

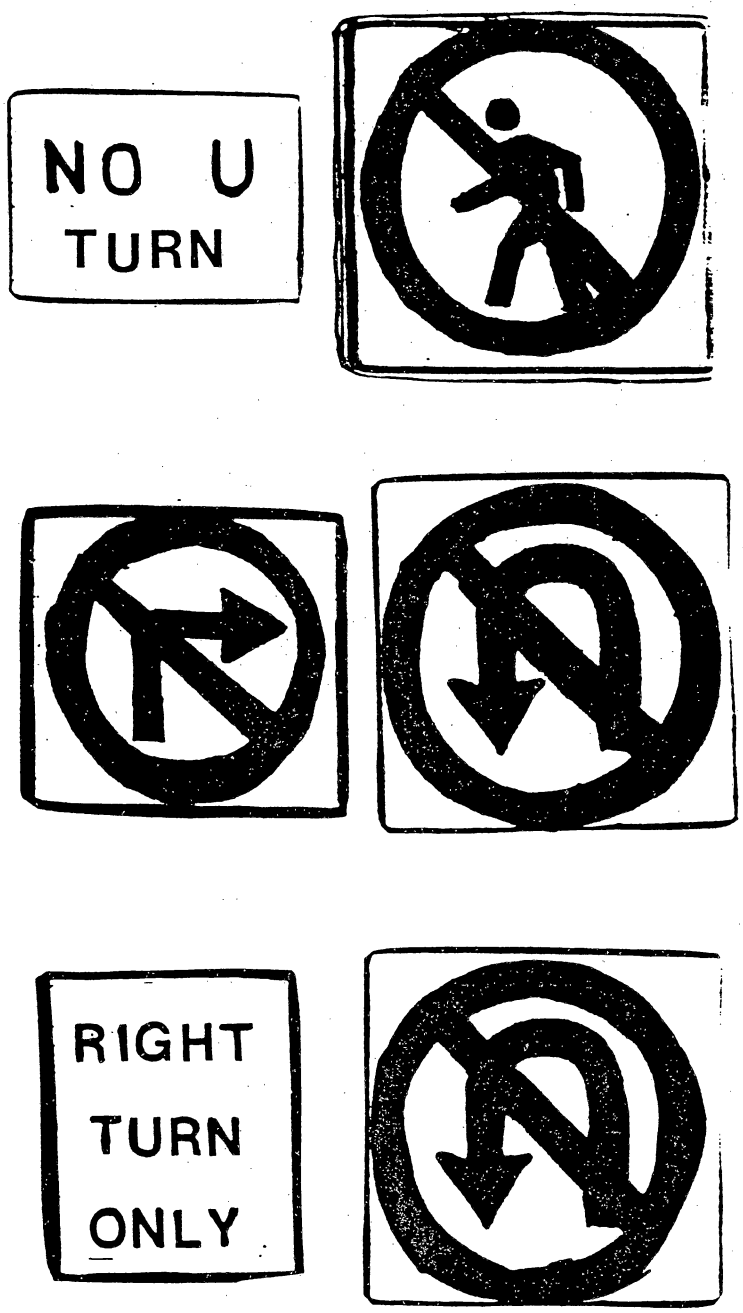






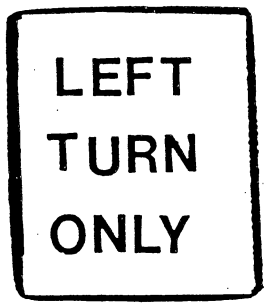
APPENDIX A (continued)

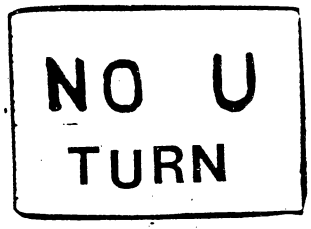
Matches & Distractors for Verbal No U Turn Standard

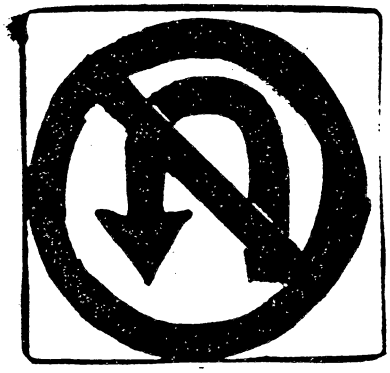


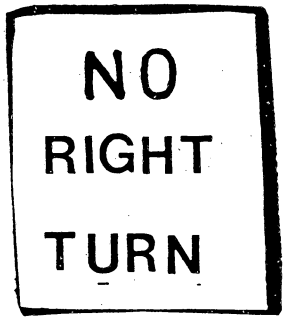
APPENDIX A (continued)

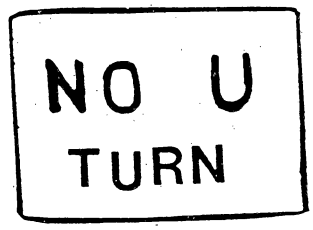
Matches & Distractors for Verbal No U Turn Standard











APPENDIX A (continued)

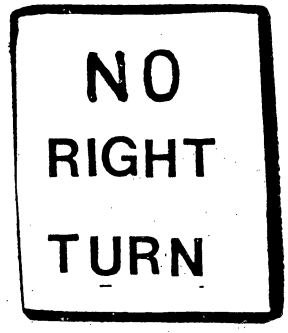
No Ped Xing (symbolic)

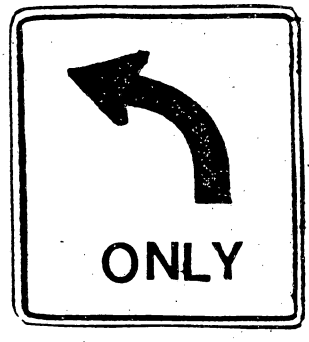
Standard

Matches and Distractors

APPENDIX A (continued)

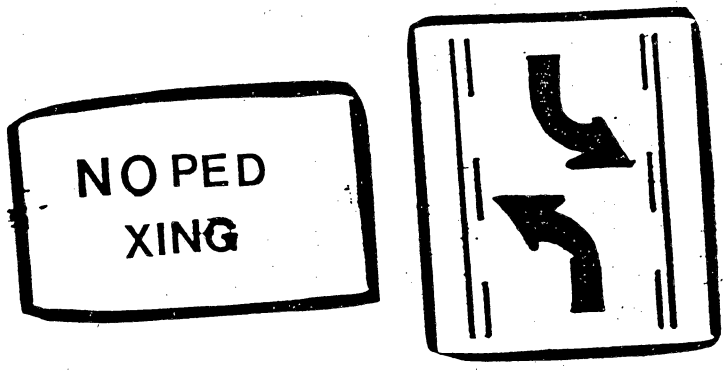
Matches & Distractors for Symbolic No Ped Xing Standard

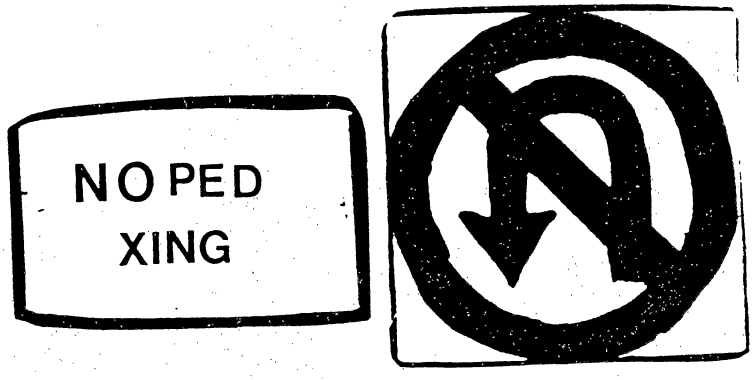




APPENDIX A (continued)

Matches & Distractors for Symbolic No Ped Xing Standard



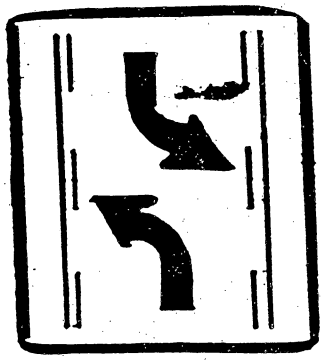


APPENDIX A (continued)

No Ped Xing (verbal)

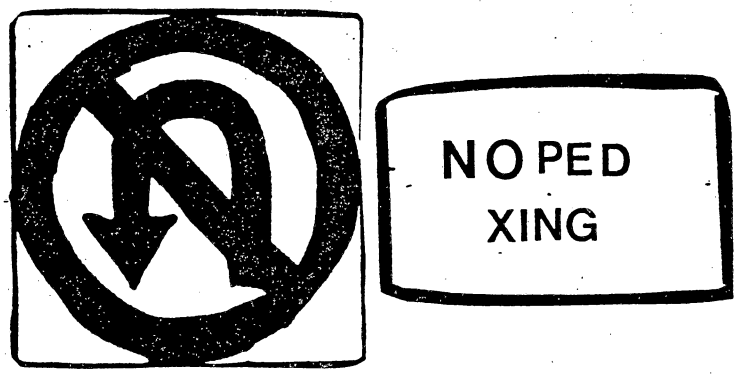
Standard

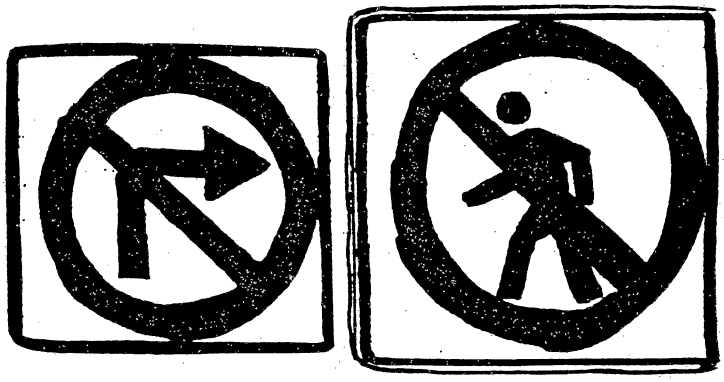
Matches and Distractors

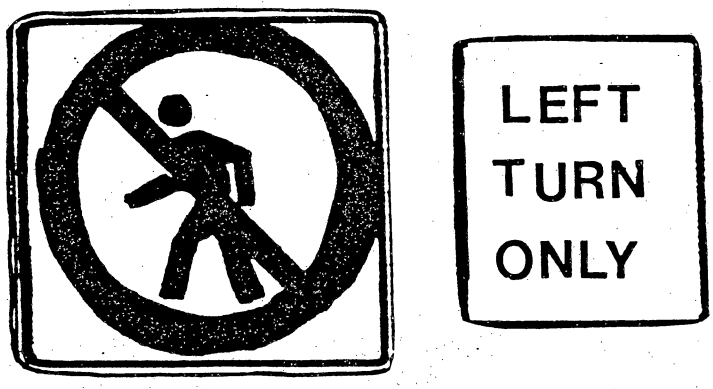


APPENDIX A (continued)

Matches & Distractors for Verbal No Ped Xing Standard

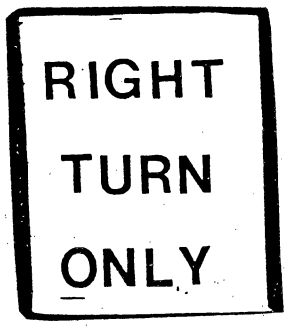


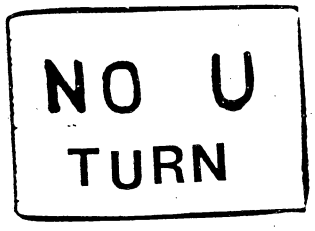




APPENDIX A (continued)

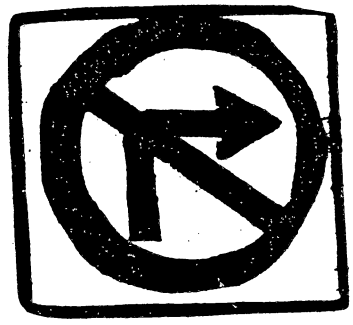
Matches & Distractors for Verbal No Ped Xing Standard





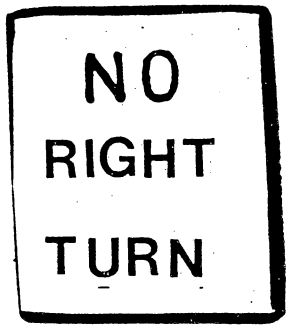
APPENDIX A (continued)

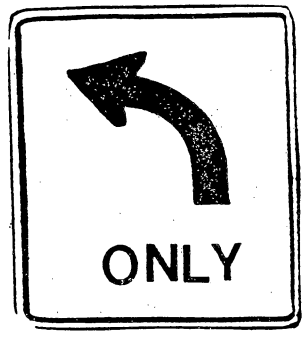
No Right Turn (symbolic)

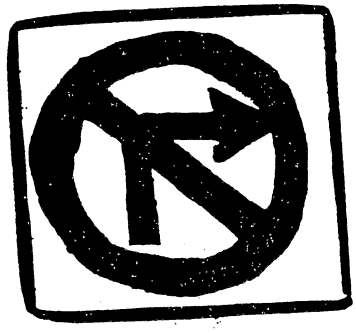


Standard

Matches and Distractors

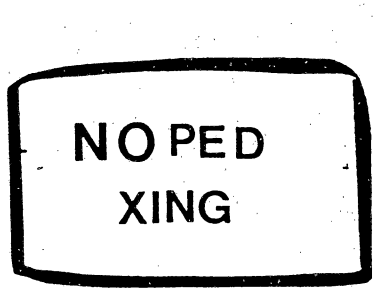


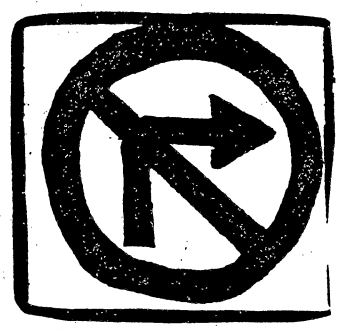


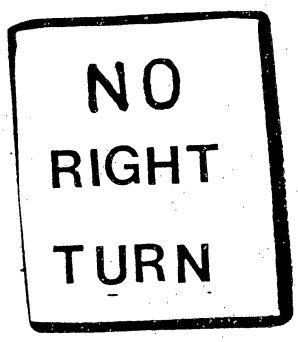


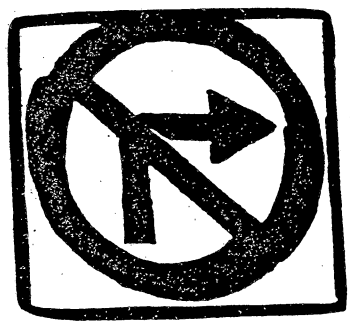
APPENDIX A (continued)

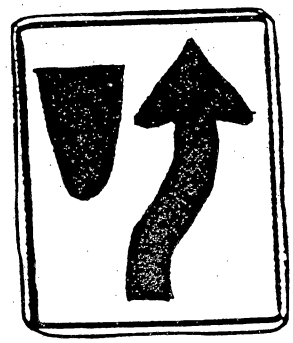
Matches & Distractors for Symbolic No Right Turn Standard





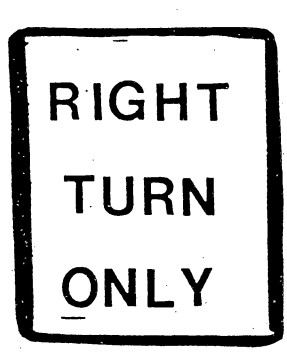


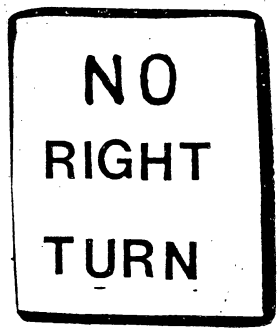


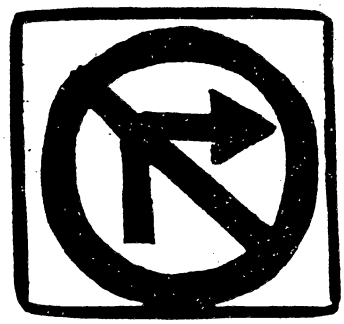


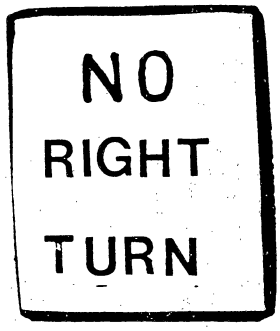
APPENDIX A (continued)

Matches & Distractors for Symbolic No Right Turn Standard



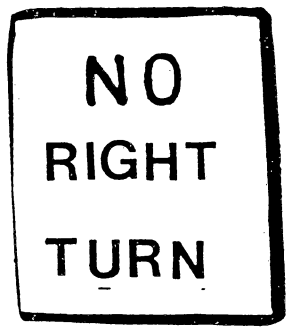






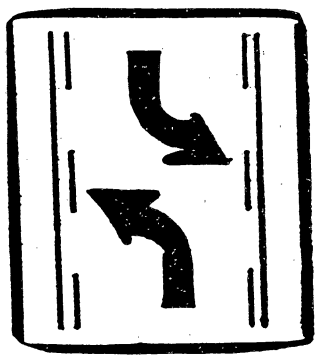
APPENDIX A (continued)

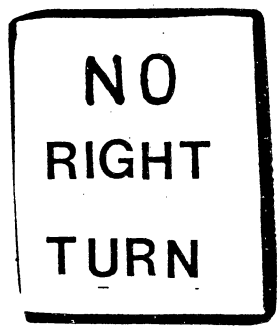
No Right Turn (verbal)

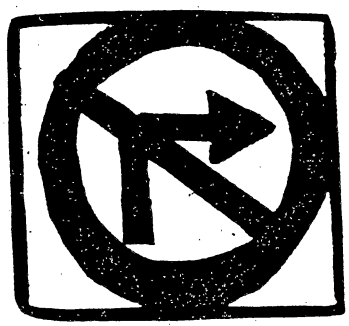


Standard

Matches and Distractors

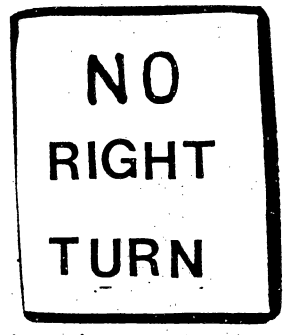


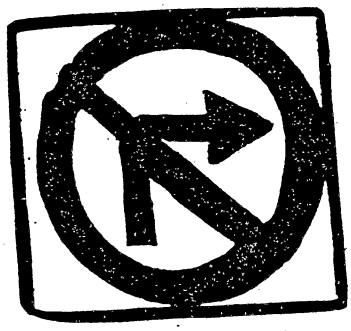


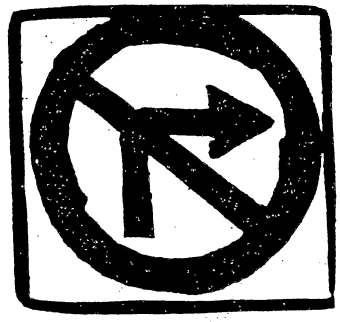


APPENDIX A (continued)

Matches & Distractors for Verbal No Right Turn Standard

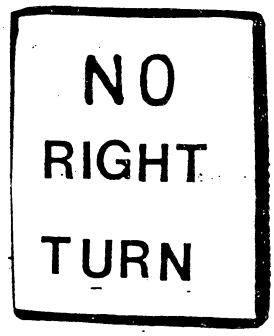


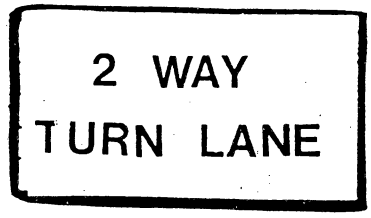


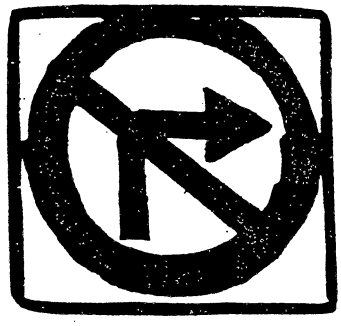


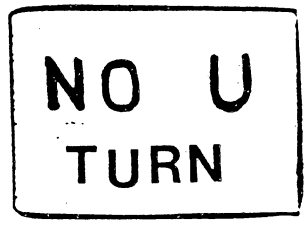
APPENDIX A (continued)

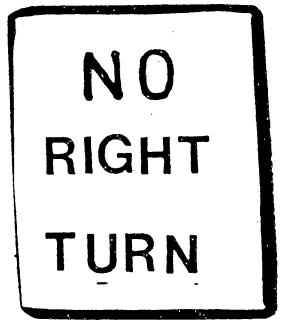
Matches & Distractors for Verbal No Right Turn Standard











APPENDIX B

Verbal Instructions to Subjects

Before we begin the actual experiment, I would like to measure your reaction time. Please rest the index finger of your right (left) hand on the raised gray dot between the response keys on the table and look through the viewfinder on the tachistoscope. I will say the word "ready" and the screen inside the tachistoscope, called the "visual field," will light up and an "X" will appear on the screen in front of you. As soon as you see the "X", press the center red button on the response keyboard. Pressing the button will stop the response timer and cause the visual field to become dark. Again I will say "ready" and shortly thereafter another "X" will appear in the visual field. Press the button again as soon as you see the "X." We will repeat the same procedure several times so that I can later compute your average response time. This is not a contest but it is important for you to respond as quickly as you can after seeing the "X."

Now I am going to show you some pictures of traffic signs. I want to find out what kinds of traffic signs are the easiest for you to recognize. This is what your task involves. I will say the word "ready" and immediately afterward a traffic sign will appear in the visual field.

As soon as you have understood the meaning of the traffic sign, press the center button on the response keyboard. Pressing the button will stop the timer on the computer and cause the first traffic sign to disappear and two more traffic signs to appear in the visual field. One of the signs will match the message of the sign you saw previously and one sign will have a different message. When you have determined which of the two signs agrees in meaning with the first sign, press the button that corresponds to the side of the visual field on which the matching sign appears. Pressing either button will stop the timer on the computer and cause the visual field to become dark. Again I will say "ready" and another single sign will appear in the visual field.

Before we go on, I am going to show you each of the signs so you will have a chance to get acquainted with the pictures and practice and feel comfortable with the procedure. We will run through them just as I described earlier. Please try to be as fast and accurate as possible when you decide which sign is the correct match. Try to relax and do your best to answer correctly. If you become tired or feel the need to take a break at any time, just let me know.

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