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Recognition Performance of Interrupted Monosyllabic Words: The Effects of Ten Interruption Locations

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Abstract

Background: A previous experiment with 70 interrupted monosyllabic words demonstrated that recognition performance was influenced by the location of an interruption pattern (Wilson, 2014). The interruption paradigm (10 interruptions/sec, 50% duty cycle periodic interruption) was referenced to word onset. The words were interrupted such that alternate 50-msec segments were parsed to separate files. In the 0-msec condition the first on-segment coincided with the word onset, whereas in the 50-msec condition the first on-segment occurred 50 msec after word onset. The 0- and 50-msec conditions were complementary halves. Recognition performance by young listeners was 19% better on the 0-msec condition (86%) than on the 50-msec condition (68%); there were a minority number of words on which the results were just the opposite. A second study using the same interruption paradigm but 300 different words reported similar relations, with 63% correct recognition on the 0-msec condition and 48% on the 50-msec condition (Wilson and Irish, 2015). Both studies suggest the importance that the first 50 msec of the target word has on intelligibility.

Purpose: To define in detail the effects that interruption patterns have on word recognition as the interruption pattern was incremented with reference to word onset from 0 to 90 msec in 10-msec steps.

Research Design: A repeated-measures design with ten interruption patterns (onset conditions).

Study Sample: Twenty-four young listeners (19–29 yr) with normal hearing for pure tones participated in this study.

Data Collection and Analyses: Seventy consonant-nucleus-consonant words formed the corpus of materials with 25 additional words used for practice. For each participant, the 700 stimuli (70 words by ten onset conditions) were interrupted (10 interruptions/sec; 50% duty cycle), randomized, and recorded on compact disc in 28, 25-word tracks.

Results: The overall mean recognition performance was 80.4% with mean performances for the ten conditions ranging from 73.0% (50-msec condition) to 87.7% (90-msec condition). The mean recognition performances changed systematically, decreasing from the 0-msec condition to the 50-msec condition and then increasing to the 90-msec condition, which formed a U-shaped function of the means. Of the 45 mean paired comparisons (post hoc *t*-tests with Bonferroni corrections), there were 17 significant differences at the $p \leq 0.001$ level, increasing to 31 significant differences when the significance level was increased to the $p \leq 0.01$ level. Visual inspection of the 70-word performance functions revealed that 32 words had flat functions, 34 words had U-shaped functions, two functions were rising, one was an inverted V-shape, and one was irregular.

Conclusions: First, some words (utterances of those words) were immune to any differential effects of the ten interruption patterns. These words with flat performance functions constituted 46% of the word

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corpus. Second, 49% of the words exhibited U-shaped performance functions that were always systematic, going from maximum to minimum and back to maximum. These words were thought to be more dependent on the initial consonant to attain maximum performance. The conclusion is that some words are not affected by the location of the interruption pattern (those with flat functions) whereas other words are substantially affected (those with U-shaped functions).

Key Words: auditory perception, interrupted words, normal hearing for pure tones, speech perception

Abbreviations: CD = compact disc; ips = interruptions/sec; NU-6 = Northwestern University Auditory Test No. 6; SD = standard deviation

INTRODUCTION

Miller (1947) and Miller and Licklider (1950) provided the early work on the effects that silent or noise interruptions have on speech recognition. Subsequently, a multitude of investigations using a variety of interruption paradigms have been reported that involve both listeners with normal hearing for pure tones and listeners with sensorineural hearing loss (e.g., Cherry, 1953; Huggins, 1964; Dirks et al, 1969; Wilson and Carhart, 1969; Powers and Speaks, 1973; Howard-Jones and Rosen, 1993; Wang and Humes, 2010; Wilson et al, 2010; Kidd and Humes, 2012). The study reported here is the third in a series of investigations from our laboratory examining the effects that the location of the interruption pattern has on word recognition performance (Wilson 2014; Wilson and Irish, 2015). All of our studies used interrupted consonant-nucleus-consonant words with periodic silent intervals (10 interruptions/sec [ips], 50% duty cycle) that produced alternating 50-msec on-segments and off-segments. The unique aspect in the three studies was that the interruption cycle was time locked to the onset of the word. The initial two studies used two interruption patterns that were the complementary halves of one another. A schematic of these two interruption patterns is shown in Supplemental Figure S1 in the Supplemental Materials (available with the online version of this article). The first pattern (0-msec condition) had the first 50-msec on-segment of the interruption cycle coincide with word onset and the second pattern (50-msec condition) had the first 50-msec off-segment of the interruption cycle coincide with word onset. The hypothesis was that overall performance on the 0-msec condition would be better than on the 50-msec condition but at the word level there would be exceptions. The results with young listeners confirmed the hypothesis by demonstrating that recognition performance on the 0-msec condition was significantly ($p < 0.001$) 15–18% better than on the 50-msec condition.

The purpose of this experiment was to define in detail the recognition performances that were obtained in an interrupted speech paradigm when the locations of the interruptions were changed systematically with respect to the onset of the target word. This detailed examination was accomplished by increasing the two interruption patterns used in our first two studies (0 and 50 msec) to ten patterns, which provided interruption patterns from 0 msec to 90 msec, in reference to word onset, in 10-msec increments.

METHODS

Materials

The materials were 70 monosyllabic consonant-nucleus-consonant words from the Northwestern University Auditory Test No. 6 (NU-6; Tillman and Carhart, 1966) recorded by a female speaker (Department of Veterans Affairs, 2006) with the carrier phrase, "Say the word _____." In a previous experiment (Wilson, 2014), the 70 words and their carrier phrases were copied to individual files with the onsets of the words defined. Then the length of the file was adjusted by inserting a silent leader at the beginning of the file (i.e., preceding the carrier phrase) so that the first on-segment of the interruption cycle coincided with the first 50 msec of the target word. An in-house interruption routine was run on each word file. For this project, the parameters of the interruption routine were set to 10 ips with a 50% duty cycle (50-msec on and 50-msec off) and no shaping of the onsets and offsets of the on-segments of the interruption cycles. The ten onset conditions are schematized in Figure 1. The mean duration of the 70 words was 487 msec (standard deviation [SD] = 77 msec), which gave the typical word 4–5 glimpses (Howard-Jones and Rosen, 1993) from which to accomplish the recognition task. A distribution of the word durations is shown in Supplemental Figure S2. The interruption routine parsed the complementary halves of the carrier phrase and target word onto the two channels of a file. For this study, initially as just described, the 0- and 50-msec onset conditions were generated. Then a 10-msec silent leader was added to the beginning of each word file, which changed the location of the interruption pattern, and the interruption routine repeated, producing the 10- and 60-msec conditions. This two-step procedure of sequentially adding an additional 10-msec silent leader at the beginning of each file and then running the interruption routine was repeated three times to produce the remaining six interruption conditions. The ten iterations of each target word then were copied to Channel 1

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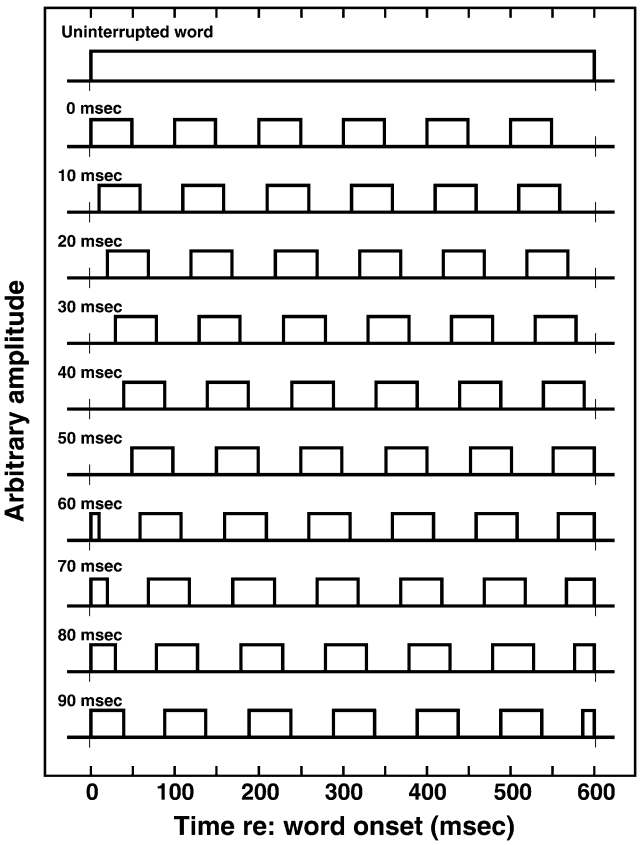

Figure 1. A schematic of the interrupted word paradigm. The stimulus conditions are indicated along the left side of the figure with the onset and offset of the target word indicated by the short, thin, vertical lines on each baseline.

of files that contained the corresponding target word uninterrupted on Channel 2, which was used to monitor the response of the listener. For each participant, the 700 stimulus files were randomized with groups of 25 words concatenated on 28 tracks that were recorded on a compact disc (CD) (16-bit, 44,100 samples/sec). Two additional tracks of the same 25 words were selected from the remaining 130 NU-6 words, randomized, and recorded on a CD for use to familiarize the participants with the listening/response task at the beginning of each experimental session.

Participants

There were three inclusion requirements for the participants who were recruited from East Tennessee State University: (a) English was the first language, (b) 18–29 yr of age, and (c) pure-tone thresholds at the octave intervals from 250 to 8000 Hz ≤20-dB HL (ANSI, 2010). The mean age of the 24 participants was 22.1 yr (SD = 3.1 yr).

Procedures

Two 1-h test sessions were required for the protocol during each of which one practice list and 14 experimental lists of interrupted words were administered. In addition, during the first session, informed consent and pure-tone thresholds were obtained. The test ear was the left ear of odd-numbered listeners and the right ear of even-numbered listeners. The interrupted speech materials, which were presented at 70 dB SPL, were reproduced by a CD player (Sony, Model CDP-CE375), fed through an audiometer (Grason-Stadler, Model 61) to a Telephonics Dynamic Headphone TDH-50P earphone encased in a MX-AR/41 cushion. The nontest ear was covered with a dummy earphone. The testing was conducted in a double-walled booth with the verbal responses of the participants recorded into a spreadsheet. The participants were reimbursed for their participation.

RESULTS AND DISCUSSION

The mean percent correct recognition data for the ten onset conditions (0–90 msec) on the 70 words by the 24 listeners with normal hearing for pure tones are illustrated in Figure 2 along with ±1 SD for the words (vertical lines). The descriptive statistics for the ten listening conditions are listed in Table 1, including SDs both for the 70 words and for the 24 participants (data for the individual words and onset conditions are listed in Supplemental Table S1). Collectively for the 700 stimulus words, the mean recognition performance was 80.4% correct (SD = 22.8%) with mean performances for the ten conditions ranging from 73.0% correct (50-msec condition) to 87.7% correct (90-msec condition) and with standard deviations ranging from 16.0% (80-msec condition) to 28.7% (40-msec condition). The arcsine transformed data (Studebaker, 1985) were subjected to a repeated-measures analysis of variance with one within-participants variable, *viz.*, onset condition (0–90 msec). The analysis of variance indicated significant

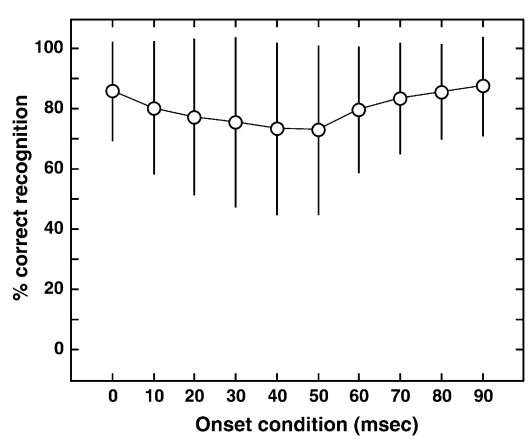

Figure 2. The mean recognition performances on the ten onset conditions obtained from the 24 listeners with normal hearing for pure tones. The vertical lines indicate ±1 SD for the 70 words. The values for the individual words are listed in Supplemental Table S1.

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Table 1. Mean % Correct Word Recognition Obtained from Young Adults with Normal Hearing

	Onset Condition (msec)									
	0	10	20	30	40	50	60	70	80	90
Mean	86.2	80.4	77.4	75.8	73.6	73.0	79.8	83.7	85.9	87.7
SD (Words)	16.6	22.1	26.2	28.2	28.7	28.1	21.1	18.6	16.0	16.2
SD (Participants)	7.8	7.8	7.3	8.0	8.5	7.5	8.5	7.6	7.0	7.5
Max	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Min	29.2	16.7	4.2	0.0	0.0	4.2	8.3	25.0	37.5	33.3
Range	70.8	83.3	95.8	100.0	100.0	95.8	91.7	75.0	62.5	66.7

Note: Also Included are ±1 SD for both the 70 words and the 24 listeners.

overall recognition performance differences among the ten onset conditions [$F_{(9,621)} = 11.14$, $p < 0.001$]. The mean absolute percent differences between the 45 possible pairs of onset conditions are listed in the lower, left triangle of data in Table 2 with the p values from post hoc t-tests with Bonferroni corrections for the 45 corresponding comparisons listed in the upper, right triangle of data. The bold numbers in the table indicate significant differences at the $p \leq 0.001$ level of which there were 17 pairs (38% of the comparisons). When the significance level is $p \leq 0.01$, the number of significant differences jumps to 31 (69% of the comparisons). Regardless of the criterion used, there are a multitude of significant differences between the 45 pairs of onset conditions. Finally, in a reflection of the symmetry observed with the mean data in Figure 2, the mean recognition performances were equal in terms of the means of the five complementary halves (i.e., 0 and 50 msec, 10 and 60 msec, etc.), ranging only 1.2% from 79.6% (0 and 50 msec) to 80.8% (30 and 80 msec).

The recognition performances as a function of the ten onset conditions for ten representative words are illustrated in Figure 3 (the functions for all 70 words are included in Supplemental Figures S3 through S9). The shapes of the 70 individual word functions, which were informally evaluated, were as follows: 34 were U-shaped (this includes 29 V-shaped response patterns; four were shallow and one was irregular), 32 were flat, 2 were rising, 1 was an inverted V-shaped, and 1 was irregular or nonsystematic. The functions illustrated in Figure 3 were classified as follows: (a) flat, *far* and *nice*; (b) U-shaped, *time*, *date*, and *sheep*; (c) shallow U-shaped, *kill* and *witch*; (d) U-shaped and irregular, *cool*; (e) irregular, *dodge*; and (f) inverted V-shaped, *beg*. Overall, the data for each word were very systematic with only a couple of words having spurious or irregular datum points. As 94% of the words had performance functions across the ten onset conditions that were either flat or U-shaped, the means for those two sets of data were calculated and are shown in Figure 4. The underlying effect is that the overall U-shaped mean function from Figure 2 becomes in Figure 4 more dramatic in shape without the tempering influences imposed by the data from the flat function. Interestingly, 26 of the 32 flat functions had all recognition performances >80% correct, which implies that those words were relatively immune to the effects of the interruptions, regardless of where in the waveform the interruptions occurred. The 34 functions that were U-shaped are much more variable and diverse in terms of the location, breadth, and depth of the minima, exhibiting little noise in the mean data. The increased variability observed with the U-shaped functions is probably attributable to the lower performances that occurred

Table 2. Absolute Differences between Mean % Correct Performances on 45 Pairs of Onset Conditions

	Onset Condition (msec)									
Onset Condition	0	10	20	30	40	50	60	70	80	90
0		**0.001**	**0.001**	**< 0.001**	**< 0.001**	**< 0.001**	0.002	0.139	0.825	0.123
10	**5.77**		0.085	0.045	0.010	0.006	0.794	0.123	0.012	**< 0.001**
20	**8.81**	3.04		0.233	0.033	0.044	0.337	0.016	0.003	**< 0.001**
30	**10.41**	4.64	1.61		0.128	0.128	0.120	0.004	**0.001**	**< 0.001**
40	**12.62**	6.85	3.81	2.20		0.690	0.013	**< 0.001**	**< 0.001**	**< 0.001**
50	**13.16**	7.38	4.35	2.74	0.54		0.006	**< 0.001**	**< 0.001**	**< 0.001**
60	6.37	0.60	2.44	4.05	6.25	6.79		0.003	**0.001**	**< 0.001**
70	2.44	3.33	6.37	7.98	**10.18**	**10.71**	3.93		0.052	0.011
80	0.30	5.48	8.51	**10.12**	**12.32**	**12.86**	**6.07**	2.14		0.155
90	1.49	**7.26**	**10.31**	**11.91**	**14.11**	**14.64**	**7.86**	3.93	1.79	

Note: Mean % correct performances are listed in the lower left triangle of data, and the corresponding p values for those differences from post hoc t-tests with Bonferroni corrections appear in the upper right triangle of data. Values in boldface indicate significant differences of $p \leq 0.001$.

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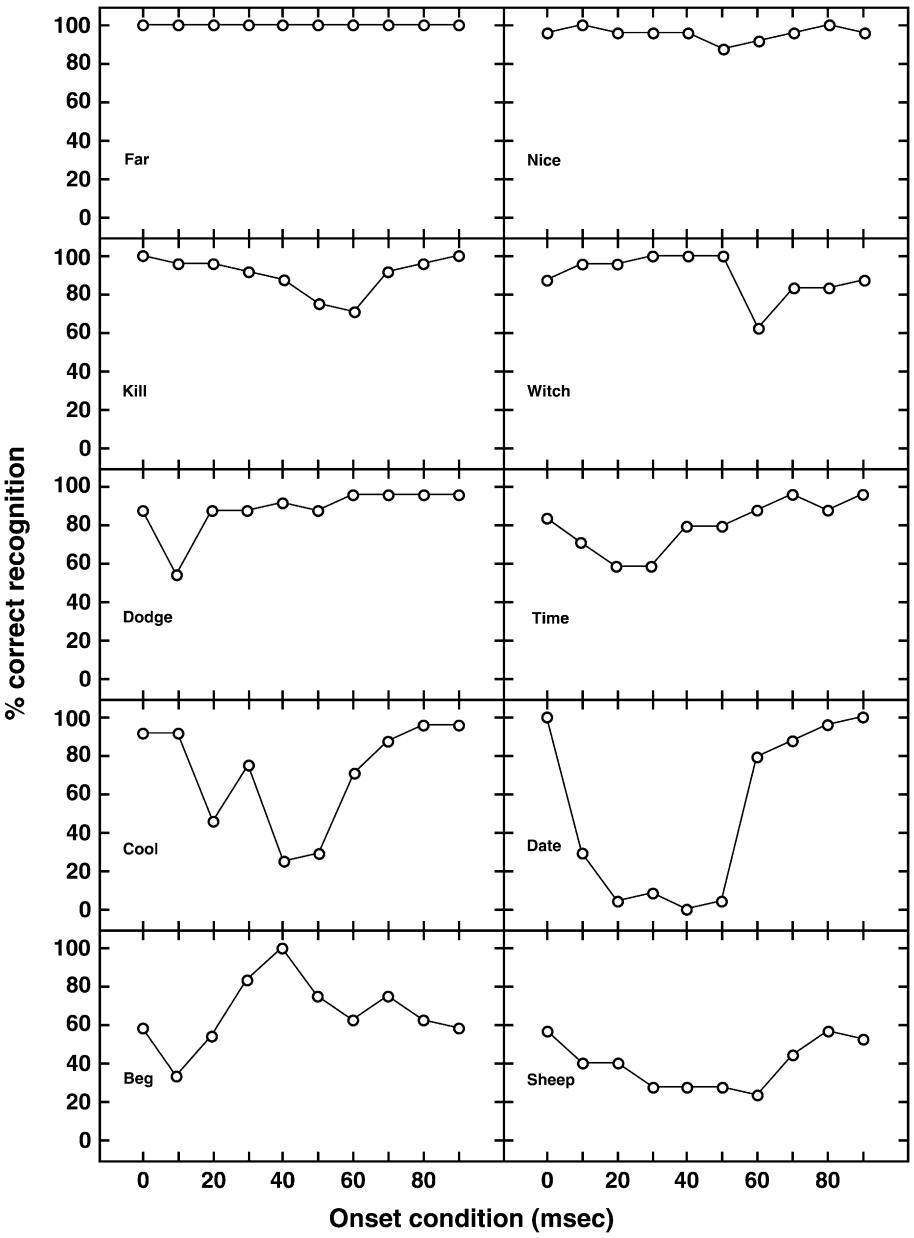

Figure 3. The percent correct recognition for the ten onset conditions of ten representative words used in this experiment. The percent correct recognition for all 70 words appear in Supplemental Table S1.

in those conditions than in the conditions associated with the flat functions. For the most part, these 34 functions were orderly in that the recognition performances steadily decreased to a minimum or minima followed by a steady increase to another maximum. This decrease and subsequent increase in performance is interpreted as reflecting the contribution to intelligibility that is made by the initial consonant, which is maximum for the onset conditions at the extremes of the onset condition continuum and minimal in the middle of the continuum. This sequence can be followed in the schematic in Figure 1. As more and more of the initial portion of the initial consonant is absent from the 10- to 50-msec conditions, recognition performance decreases; then, as more and more of the initial portion of the initial consonant reappears from 60 to 90 msec, performance increases.

This study included two conditions (0 and 50 msec) that were included in the Wilson (2014, Supplemental Table S1) study. Figure 5 contains bivariate plots of the earlier data (ordinate) and the current data (abscissa) for each of the 70 words used in both studies. Overall and especially for the datum points <80%, the majority of points are below the diagonal line of equality indicating better performances by the participants in this study. This is not an unexpected finding because the

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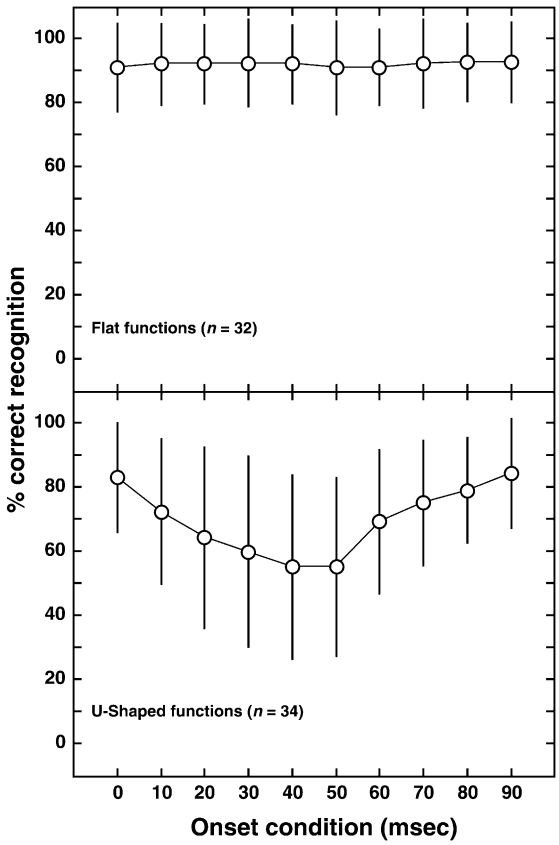

Figure 4. The mean recognition performances on the ten onset conditions obtained from the 24 listeners with normal hearing on the 32 words with flat functions (top) and the 34 words with U-shaped functions (bottom). The vertical lines indicate ±1 SD. The values for the individual words are listed in Supplemental Table S1.

listeners in this study had substantially more listening experience with the interrupted word paradigm and the 70 words than did the listeners in the earlier study, that is, the listeners in this study had ten exposures to each word whereas the listeners in the earlier study had four exposures to each word. The slopes of the regressions in Figure 5 were close to unity, 0.80%/% (0 msec) and 0.96%/% (50 msec), indicating that the recognition performances on each word were similar in the two studies, just displaced to slightly higher performance levels in this study. The data in Figure 5 demonstrate good consistency in recognition performances on the 70 select words by two young listener groups with normal hearing for pure tones.

Finally, a comment about the recognition performance on the two practice lists and across the 14, 25-word tracks given in each of the two sessions is instructive. Before the experimental conditions in the two test sessions, a practice list of interrupted words (0-msec condition) was administered to acquaint the listener with the interrupted speech task. The same 25 words were used in both practice sessions with different randomizations used both within and between participants. A 12.5% improvement in recognition performance on the practice lists was observed between session 1 (mean = 67.0%; SD = 10.2%) and session 2 (mean = 79.5%, SD = 10.0%), which was a significant difference [$t_{(24)} = -6.27$, $p < 0.001$]. As illustrated with the bivariate plot in Figure 6 of the recognition performances on the 25 practice words during the two sessions, almost all of the datum points are below the line of equality indicating better performances were obtained in the second session. The results for the words are fairly consistent between sessions in that performances on each word maintained their relative relations. The linear regression indicates that the most improvement in recognition performance occurred with those words exhibiting the poorest performances, which is an effect commonly observed across trials. The 12.5% improvement in performance on the practice lists of 25 words between sessions is attributed to the listeners learning to listen and respond to the interrupted words, which are a form of a distorted speech task. A smaller, but significant [$t_{(46)} = -2.19$, $p < 0.05$], 5% improvement in performance was observed between

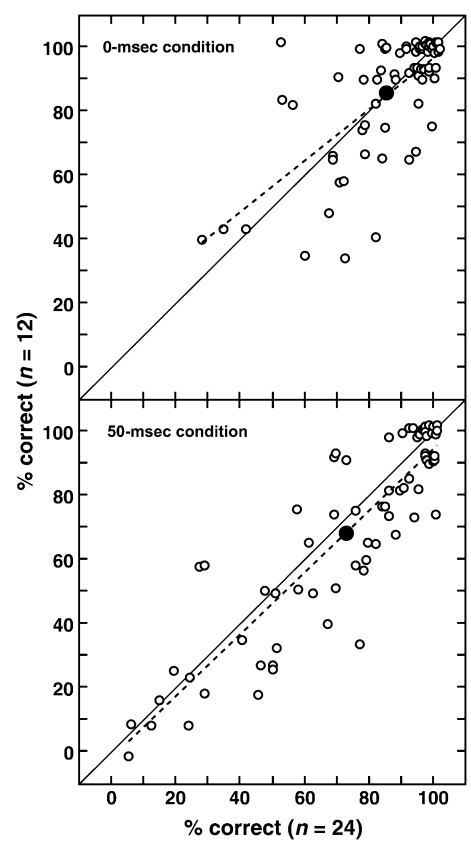

Figure 5. The mean recognition performances on the 70 interrupted words in the two onset conditions used in this study (n = 24) and in the Wilson (2014) study (n = 12). The large, filled symbols represent the mean performances and the dashed lines are the linear regressions used to describe the data (0 msec, y = 17.046 + 0.80×, R^2 = 0.48; 50 msec, y = −1.877 + 0.96×, R^2 = 0.79). The data were jittered using a random, additive algorithm.

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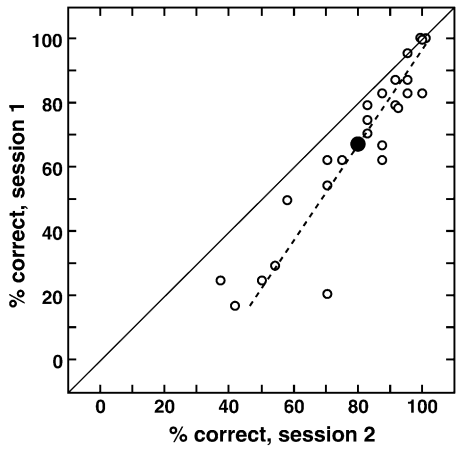

Figure 6. The mean recognition performances on the 25 interrupted words used as practice for each of the two test sessions. The large, filled symbol represents the mean performances and the dashed line is the linear regression used to describe the data ($y = 35.275 + 0.668\times$, $R^2 = 0.86$). The data were jittered using a random, additive algorithm. The data for the individual words are listed in Supplemental Table S2.

the materials presented in the first experimental session (mean = 77.2%, SD = 8.3%) and the second session (mean = 82.2%, SD = 8.0%). Linear regressions across the 14 tracks in the two experimental sessions revealed slopes of 0.67%/track (session 1) and 0.16%/track (session 2). Thus, as with the practice lists, learning/practice across the experimental conditions occurred mostly in the first session. These differences underscore the importance that practice and randomization of the stimulus materials have on recognition performance, especially when the listening task involves a distorted speech signal.

CONCLUSIONS

The initial studies of the effects that the location of the interruption patterns in the word had on recognition performance revealed that in general, location did make a difference in that performance was usually better in the 0-msec condition than in the 50-msec condition (Wilson, 2014; Wilson and Irish, 2015). This study systematically increased the number of onset conditions from two to ten, thereby providing a more detailed examination of how interruption pattern location affects recognition performance. The basic findings that emerged were, yes, the location of the interruptions in a word does affect recognition performance in two major ways. First, there were 46% of the words (at least utterances of those words) on which performance was relatively unchanged as the interruption location was varied from 0 msec to 90 msec, that is, the recognition performances across the ten onset conditions were flat. These words with flat recognition functions across the onset conditions seemingly are so redundant in the information they contain, perhaps throughout the waveform, that intelligibility is not disrupted by the interruption algorithm. Second, there were 49% of the words on which recognition performance was maximum at the extremes of the interruption continuum (i.e., the 0-, 10-, 80-, and 90-msec conditions) and minimum between the extremes, that is, the recognition performance functions were U-shaped. These particular utterances of the words are thought to rely intelligibility-wise in great part on the information provided by the initial milliseconds of the initial consonant. There definitely were differences among the words in the way intelligibility was affected by the location of the interruption pattern. Perhaps even each different utterance of the same word would be differentially affected by the location of the interruption pattern. The fact remains that our understanding is rudimentary regarding of what cues in individual utterances of words are the major contributors to intelligibility. Future studies using the interrupted word paradigm need to be aware of how the location of the interruption pattern of each word affects intelligibility for both listeners with normal hearing and listeners with sensorineural hearing loss.

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Supplemental Table S1

Table S1. The mean percent correct recognitions for the 10 interrupted conditions of each of the 70 words. The words are ranked by their overall mean recognition performances (right-most column).

		Onset Condition (msec)										
	Word	0	10	20	30	40	50	60	70	80	90	Mean
1	FAR	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
2	HIRE	100.0	100.0	95.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.6
3	FOOD	100.0	100.0	100.0	100.0	100.0	95.8	100.0	100.0	100.0	95.8	99.2
4	GOOD	100.0	100.0	100.0	100.0	95.8	95.8	100.0	100.0	100.0	100.0	99.2
5	HAVE	100.0	100.0	100.0	100.0	100.0	95.8	100.0	95.8	100.0	100.0	99.2
6	LONG	100.0	100.0	100.0	95.8	95.8	100.0	100.0	100.0	95.8	95.8	98.3
7	PAIN	100.0	100.0	100.0	100.0	100.0	95.8	95.8	91.7	100.0	100.0	98.3
8	YOUNG	95.8	95.8	100.0	100.0	100.0	100.0	95.8	100.0	95.8	100.0	98.3
9	LIFE	100.0	95.8	100.0	100.0	95.8	95.8	100.0	95.8	95.8	100.0	97.9
10	WIRE	95.8	100.0	100.0	95.8	95.8	100.0	95.8	100.0	100.0	95.8	97.9
11	ROAD	100.0	95.8	95.8	95.8	95.8	95.8	100.0	100.0	100.0	100.0	97.9
12	LEARN	95.8	95.8	95.8	100.0	95.8	95.8	100.0	100.0	95.8	100.0	97.5
13	YOUTH	95.8	100.0	100.0	100.0	100.0	95.8	91.7	95.8	100.0	95.8	97.5
14	REED	87.5	100.0	100.0	100.0	100.0	100.0	95.8	100.0	100.0	91.7	97.5
15	RED	100.0	100.0	100.0	100.0	95.8	91.7	100.0	100.0	87.5	95.8	97.1
16	CHAIR	100.0	100.0	95.8	100.0	100.0	91.7	95.8	87.5	95.8	100.0	96.7
17	DOG	100.0	95.8	100.0	100.0	83.3	83.3	100.0	100.0	100.0	100.0	96.3
18	HATE	100.0	83.3	83.3	95.8	100.0	95.8	100.0	100.0	100.0	100.0	95.8
19	JUDGE	95.8	95.8	100.0	100.0	100.0	83.3	100.0	95.8	95.8	87.5	95.4
20	NICE	95.8	100.0	95.8	95.8	95.8	87.5	91.7	95.8	100.0	95.8	95.4
21	BACK	95.8	100.0	95.8	91.7	91.7	100.0	87.5	91.7	95.8	95.8	94.6
22	LIVE	95.8	91.7	91.7	91.7	100.0	100.0	91.7	95.8	91.7	95.8	94.6
23	KICK	91.7	95.8	87.5	91.7	87.5	100.0	100.0	100.0	91.7	95.8	94.2
24	RING	83.3	100.0	91.7	95.8	95.8	95.8	91.7	100.0	91.7	95.8	94.2
25	MAKE	79.2	87.5	87.5	95.8	100.0	100.0	100.0	100.0	95.8	91.7	93.8
26	LUCK	95.8	83.3	91.7	87.5	83.3	95.8	95.8	95.8	100.0	100.0	92.9
27	VOICE	83.3	87.5	95.8	100.0	100.0	100.0	87.5	87.5	91.7	91.7	92.5
28	BATH	95.8	95.8	91.7	87.5	91.7	79.2	79.2	95.8	95.8	95.8	90.8
29	KILL	100.0	95.8	95.8	91.7	87.5	75.0	70.8	91.7	95.8	100.0	90.4
30	WITCH	87.5	95.8	95.8	100.0	100.0	100.0	62.5	83.3	83.3	87.5	89.6
31	SOUR	95.8	79.2	79.2	91.7	79.2	79.2	83.3	95.8	100.0	100.0	88.3
32	DODGE	87.5	54.2	87.5	87.5	91.7	87.5	95.8	95.8	95.8	95.8	87.9
33	CHIEF	79.2	87.5	95.8	87.5	95.8	87.5	75.0	83.3	91.7	87.5	87.1
34	NOTE	70.8	87.5	100.0	100.0	95.8	100.0	95.8	75.0	54.2	75.0	85.4
35	SOAP	95.8	91.7	83.3	87.5	66.7	79.2	75.0	87.5	87.5	100.0	85.4
36	MOOD	95.8	91.7	100.0	95.8	95.8	91.7	87.5	54.2	41.7	87.5	84.2
37	DOLL	91.7	79.2	91.7	79.2	79.2	50.0	87.5	95.8	95.8	79.2	82.9
38	RUSH	79.2	83.3	83.3	91.7	79.2	87.5	70.8	83.3	70.8	83.3	81.3
39	JUICE	95.8	95.8	91.7	100.0	79.2	75.0	50.0	62.5	79.2	83.3	81.3
40	TIME	83.3	70.8	58.3	58.3	79.2	79.2	87.5	95.8	87.5	95.8	79.6
41	WHEAT	66.7	50.0	91.7	87.5	91.7	91.7	79.2	79.2	75.0	83.3	79.6
42	TURN	100.0	95.8	66.7	50.0	58.3	50.0	87.5	83.3	100.0	100.0	79.2
43	LATE	70.8	58.3	45.8	54.2	66.7	91.7	100.0	95.8	91.7	100.0	77.5
44	MESS	70.8	58.3	83.3	75.0	66.7	70.8	87.5	91.7	91.7	79.2	77.5
45	SUCH	87.5	75.0	75.0	75.0	62.5	62.5	70.8	87.5	87.5	87.5	77.1
46	SEARCH	70.8	79.2	87.5	83.3	62.5	83.3	75.0	70.8	83.3	70.8	76.7
47	HAZE	83.3	79.2	66.7	62.5	83.3	70.8	79.2	75.0	79.2	83.3	76.3
48	GAS	79.2	83.3	62.5	54.2	62.5	70.8	91.7	87.5	75.0	87.5	75.4
49	PICK	95.8	87.5	83.3	50.0	62.5	41.7	62.5	79.2	91.7	95.8	75.0
50	TIRE	100.0	70.8	70.8	70.8	45.8	45.8	79.2	83.3	79.2	95.8	74.2
51	BITE	83.3	91.7	79.2	70.8	54.2	62.5	58.3	62.5	75.0	95.8	73.3
52	TOOL	100.0	100.0	100.0	54.2	29.2	25.0	66.7	66.7	87.5	95.8	72.5
53	GAZE	70.8	75.0	83.3	83.3	79.2	45.8	79.2	66.7	66.7	70.8	72.1
54	COOL	91.7	91.7	45.8	75.0	25.0	29.2	70.8	87.5	95.8	95.8	70.8

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Supplemental Table S1

Table S1, continued

55	DITCH	91.7	70.8	50.0	50.0	37.5	25.0	79.2	83.3	95.8	100.0	68.3
56	GET	83.3	91.7	62.5	33.3	41.7	58.3	70.8	91.7	79.2	70.8	68.3
57	PASS	79.2	70.8	62.5	45.8	54.2	66.7	58.3	95.8	83.3	62.5	67.9
58	TALK	100.0	75.0	66.7	62.5	45.8	58.3	33.3	58.3	79.2	100.0	67.9
59	SHAWL	83.3	70.8	70.8	79.2	54.2	50.0	54.2	58.3	70.8	75.0	66.7
60	BEG	58.3	33.3	54.2	83.3	100.0	75.0	62.5	75.0	62.5	58.3	66.3
61	GUN	95.8	70.8	33.3	20.8	29.2	29.2	83.3	83.3	91.7	100.0	63.8
62	DAB	83.3	58.3	25.0	16.7	29.2	45.8	83.3	75.0	79.2	70.8	56.7
63	MOUSE	54.2	50.0	29.2	37.5	50.0	70.8	50.0	70.8	83.3	54.2	55.0
64	DATE	100.0	29.2	4.2	8.3	0.0	4.2	79.2	87.5	95.8	100.0	50.8
65	BASE	58.3	16.7	20.8	37.5	29.2	50.0	62.5	66.7	70.8	70.8	48.3
66	SHACK	54.2	54.2	37.5	33.3	20.8	25.0	33.3	45.8	54.2	75.0	43.3
67	HALF	29.2	33.3	37.5	29.2	41.7	20.8	45.8	29.2	37.5	33.3	33.8
68	DEEP	70.8	37.5	8.3	0.0	0.0	4.2	37.5	41.7	62.5	54.2	31.7
69	CALM	33.3	33.3	29.2	16.7	25.0	12.5	20.8	25.0	45.8	41.7	28.3
70	SHEEP	41.7	25.0	25.0	12.5	12.5	12.5	8.3	29.2	41.7	37.5	24.6
	Mean	86.2	80.4	77.4	75.8	73.6	73.0	79.8	83.7	85.9	87.7	80.4
	SD (Words)	16.6	22.1	26.2	28.2	28.7	28.1	21.1	18.6	16.0	16.2	18.8
	SD (Subjects)	7.8	7.8	7.3	8.0	8.5	7.5	8.5	7.6	7.0	7.5	7.7
	Max	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Min	29.2	16.7	4.2	0.0	0.0	4.2	8.3	25.0	37.5	33.3	24.6
	Range	70.8	83.3	95.8	100.0	100.0	95.8	91.7	75.0	62.5	66.7	75.4

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Table S2. The mean performances (%) obtained on the practice lists at the beginning of the first session (S1) and the second session (S2) are listed for each of the 25 words interrupted with the 0-ms condition. The S2 minus S1 difference also is listed.

	Word	Session 1	Session 2	S2 - S1
1	FIT	70.8	83.3	12.5
2	PEG	87.5	91.7	4.2
3	ROSE	83.3	87.5	4.2
4	WALK	100.0	100.0	0.0
5	WHEN	87.5	95.8	8.3
6	BONE	100.0	100.0	0.0
7	CHECK	20.8	70.8	50.0
8	NEAT	50.0	58.3	8.3
9	SHIRT	54.2	70.8	16.7
10	VOTE	66.7	87.5	20.8
11	HALL	79.2	91.7	12.5
12	JUG	79.2	91.7	12.5
13	NEAR	95.8	95.8	0.0
14	PHONE	100.0	100.0	0.0
15	THIN	62.5	75.0	12.5
16	CAUSE	75.0	83.3	8.3
17	LEAN	83.3	95.8	12.5
18	CHAT	25.0	37.5	12.5
19	SHOULD	83.3	100.0	16.7
20	SEIZE	16.7	41.7	25.0
21	HOLE	79.2	83.3	4.2
22	LEASE	25.0	50.0	25.0
23	LID	29.2	54.2	25.0
24	PEARL	62.5	87.5	25.0
25	YEARN	62.5	70.8	8.3
	Mean	67.2	80.2	13.0
	SD	26.1	18.9	11.2
	Max	100.0	100.0	50.0
	Min	16.7	37.5	0.0
	Range	83.3	62.5	50.0

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Supplemental Figure S1

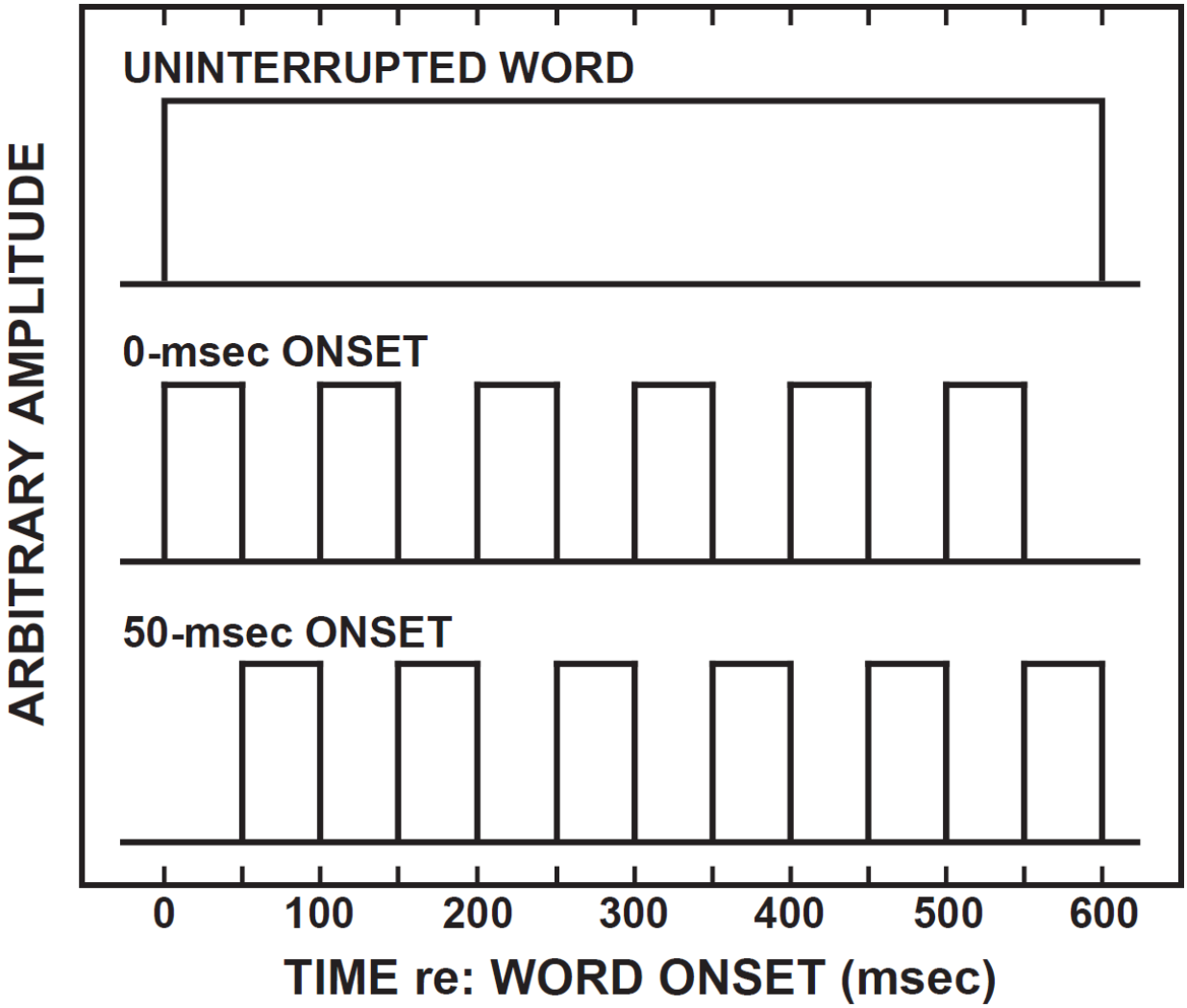

Figure S1. A schematic illustrating how the uninterrupted word (top) is interrupted (10 ips, 50% duty cycle) into complementary halves (0-msec and 50-msec conditions; middle and bottom) with word onset as the reference.

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Supplemental Figure S2

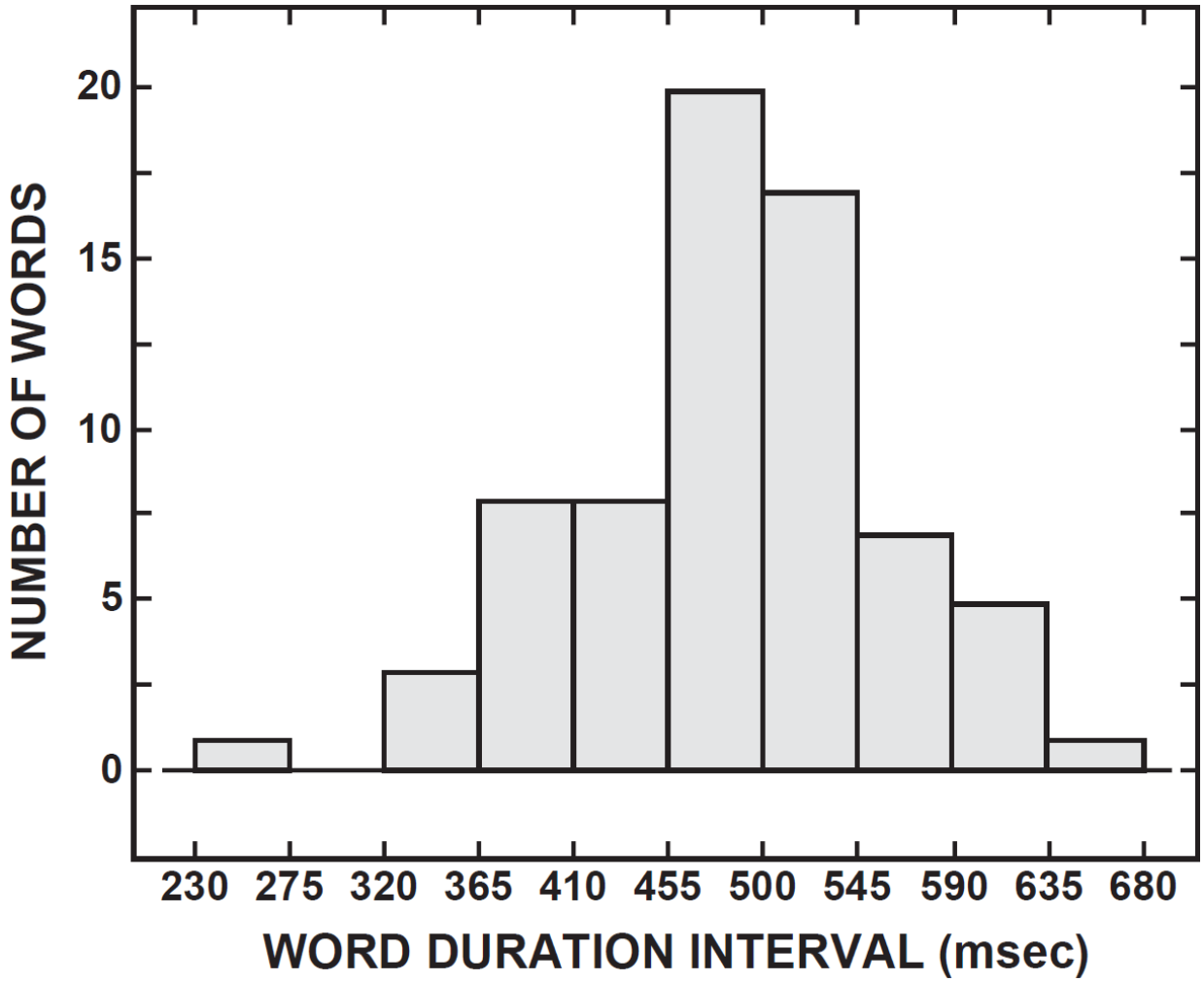

Figure S2. A distribution of the durations of the 70 NU-6 words used in the current experiment.

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Supplemental Figure S3

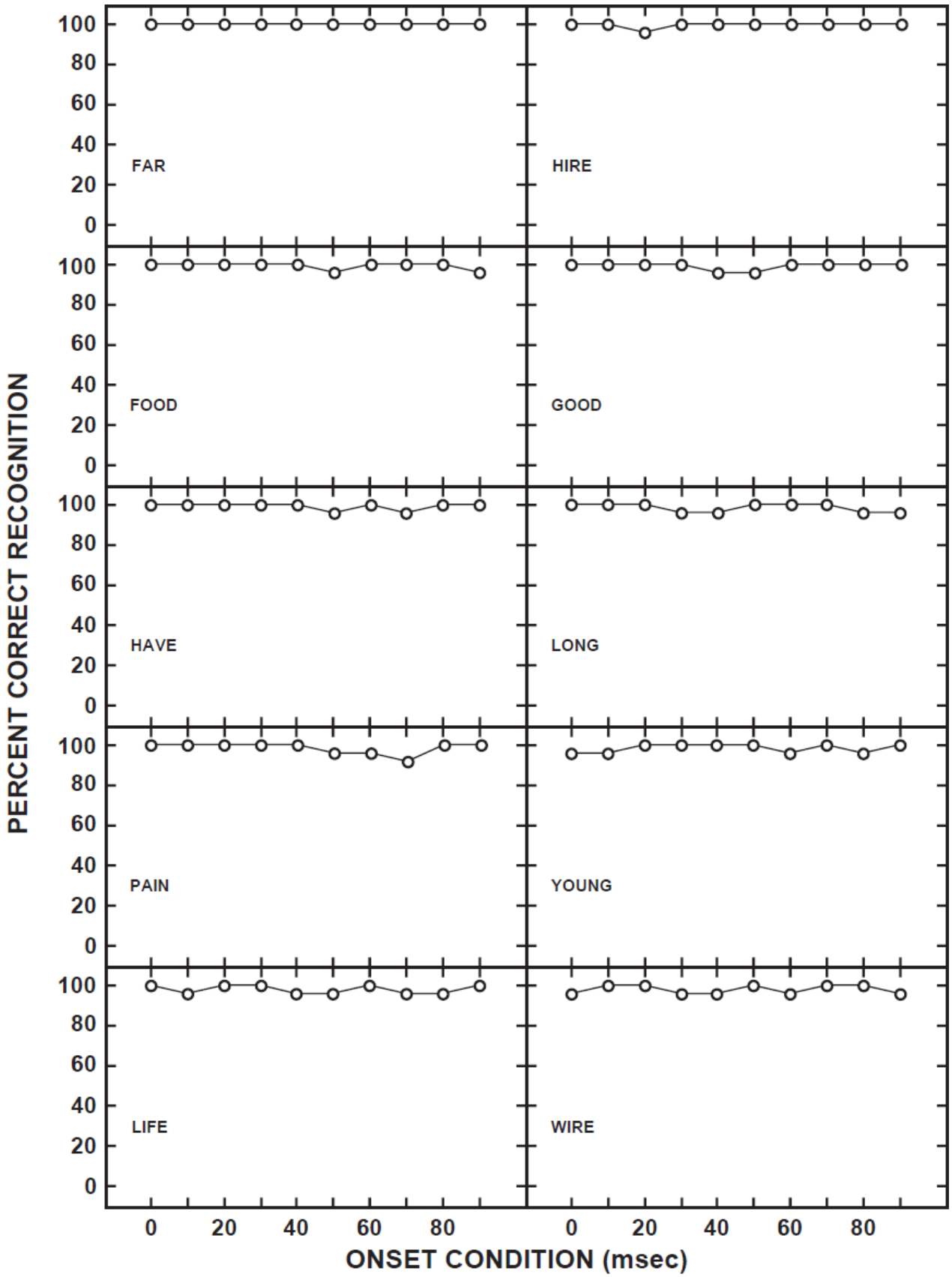

Figure S3. The percent correct recognition for the 10 onset conditions of words 1-10 used in the current experiment. The data are listed in Table S1.

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Supplemental Figure S4

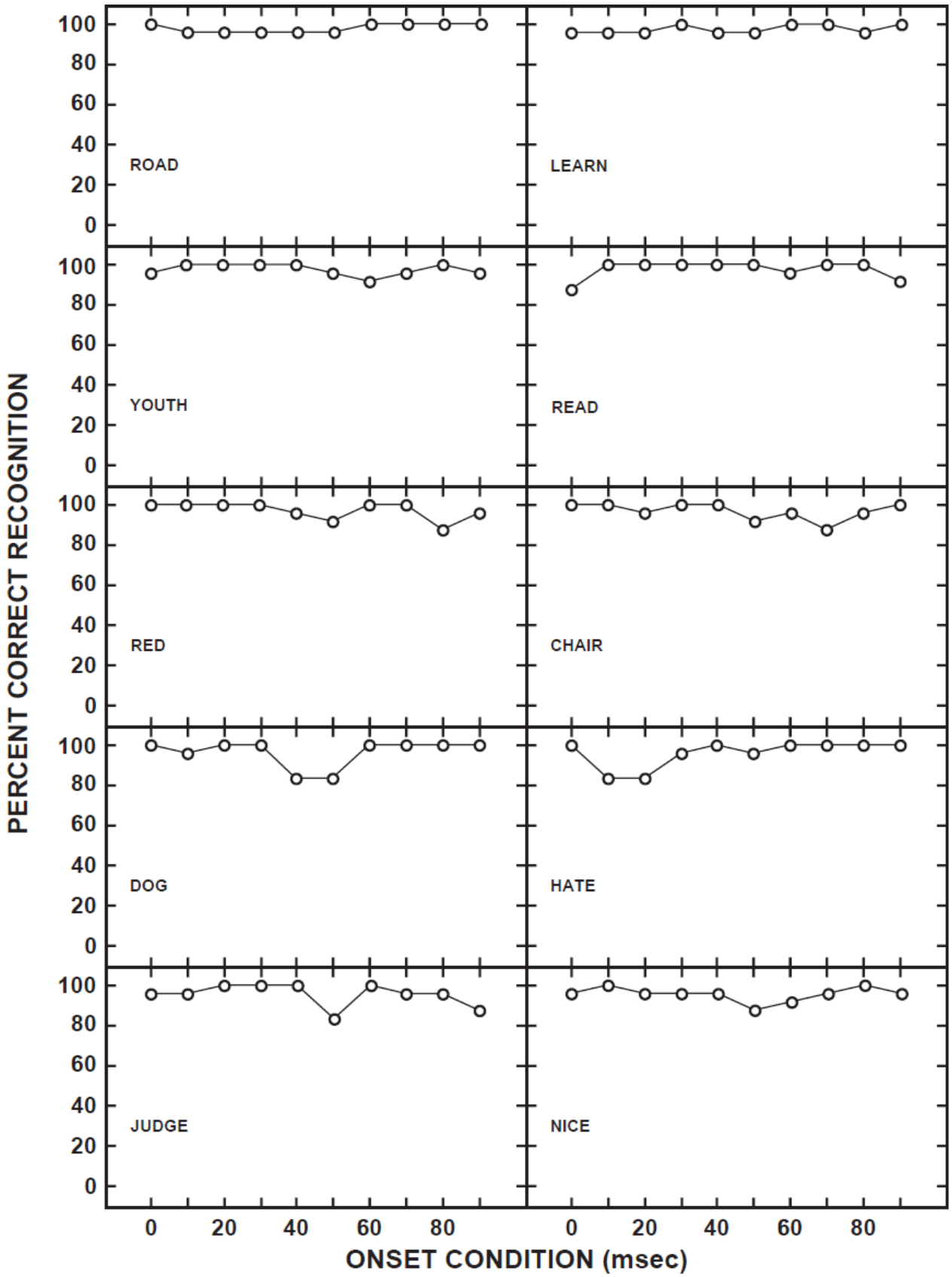

Figure S4. The percent correct recognition for the 10 onset conditions of words 11-20 used in the current experiment. The data are listed in Table S1.

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Supplemental Figure S5

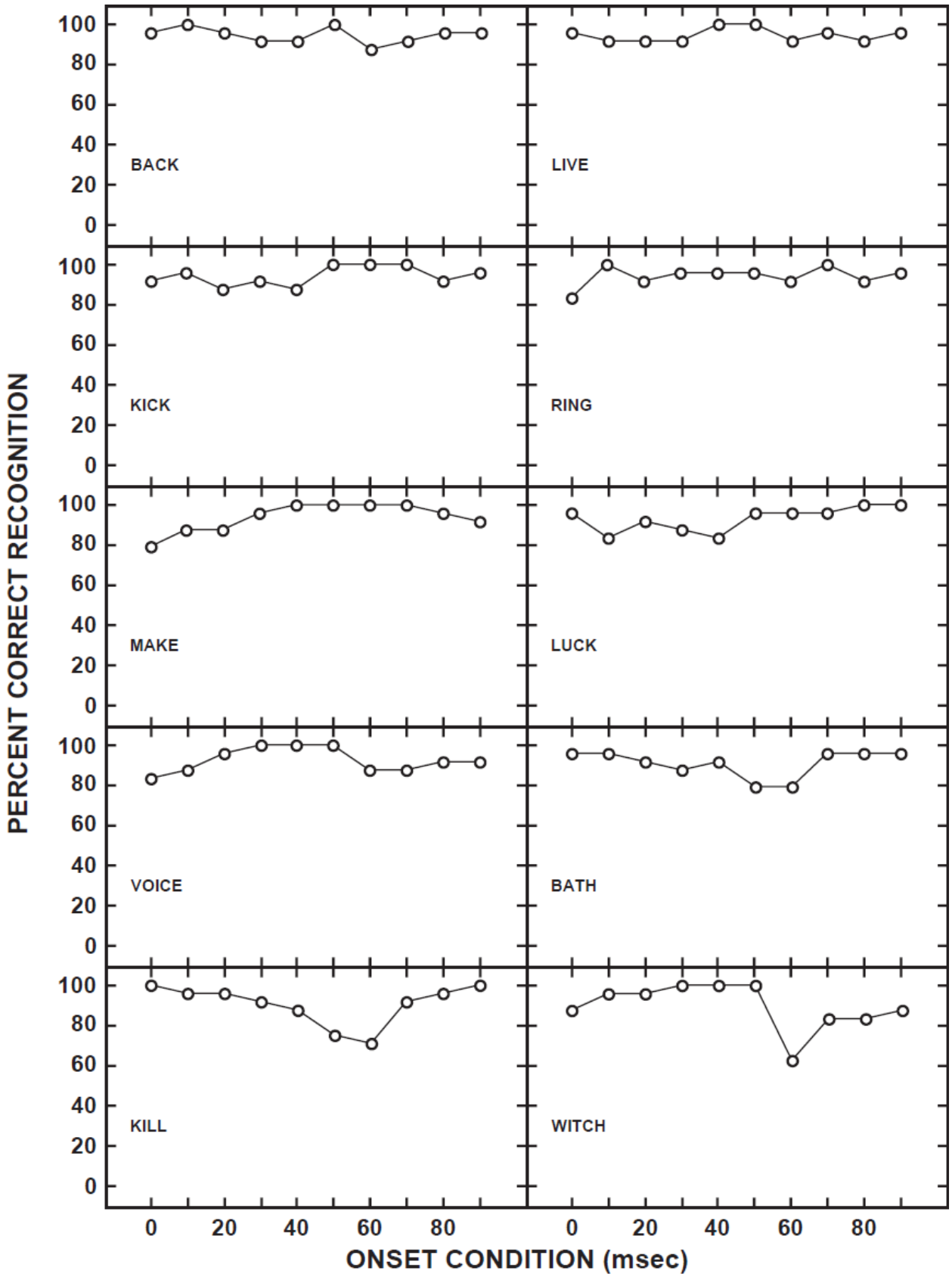

Figure S5. The percent correct recognition for the 10 onset conditions of words 21-30 used in the current experiment. The data are listed in Table S1.

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Supplemental Figure S6

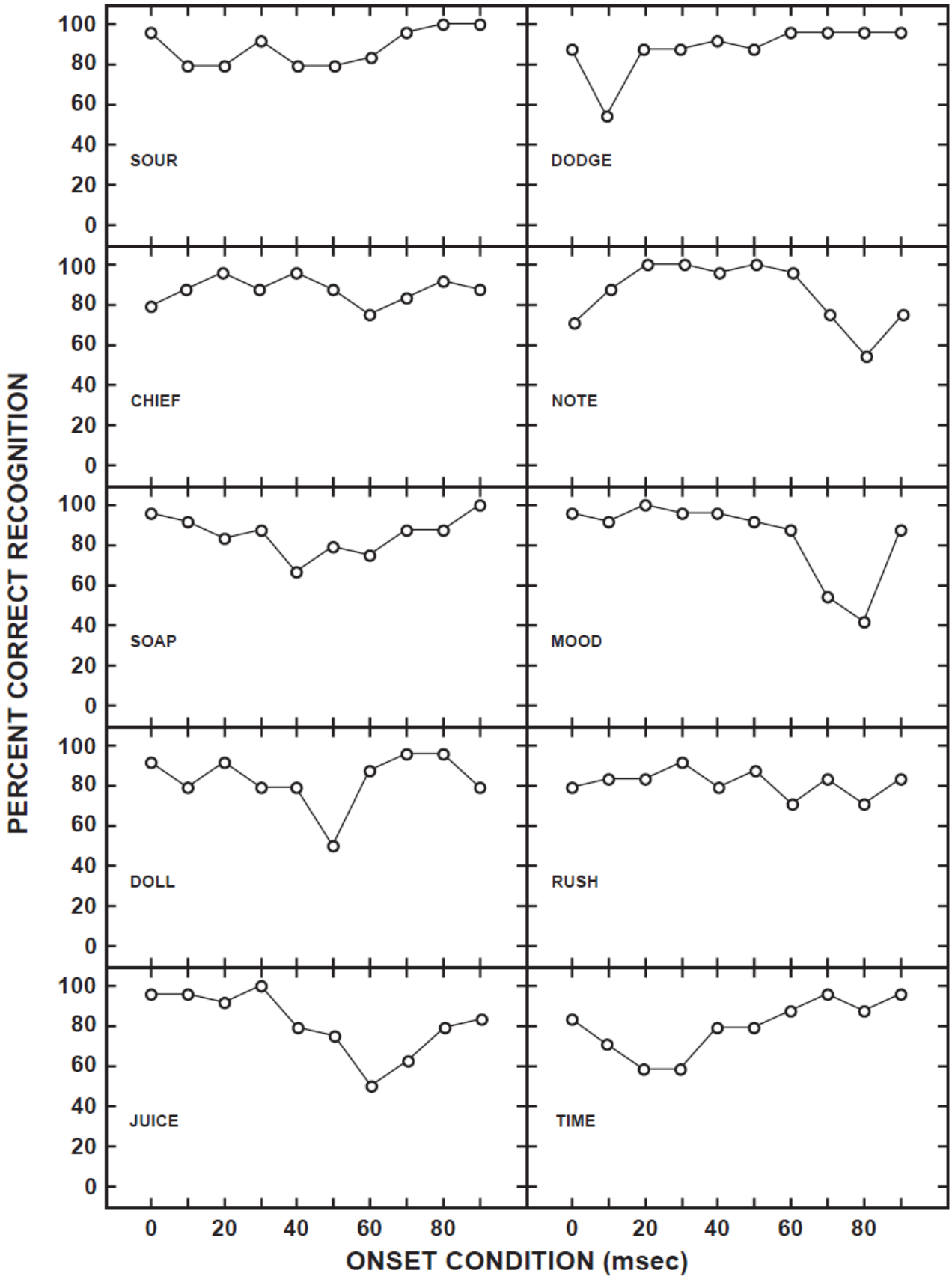

Figure S6. The percent correct recognition for the 10 onset conditions of words 31-40 used in the current experiment. The data are listed in Table S1.

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Supplemental Figure S7

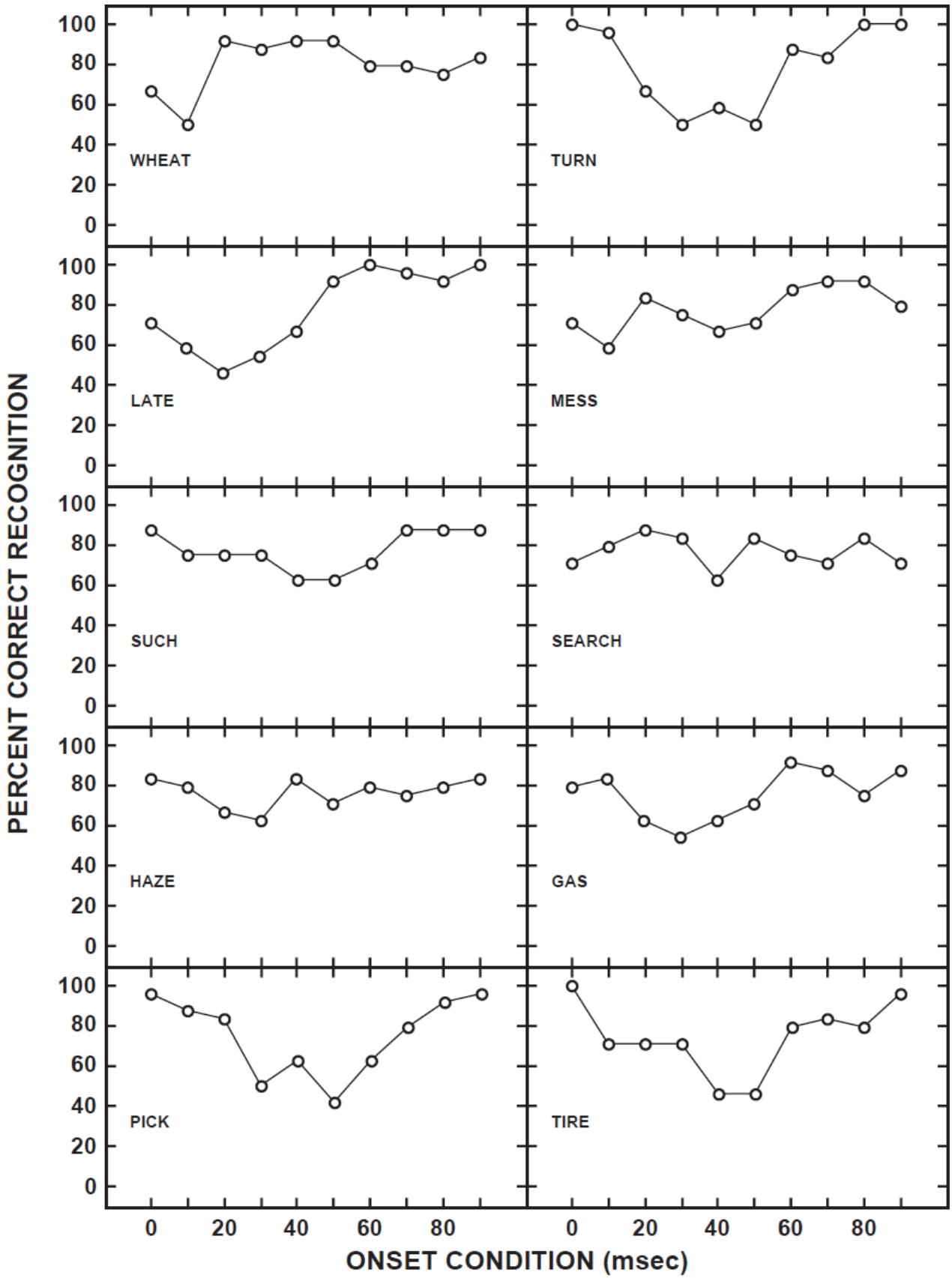

Figure S7. The percent correct recognition for the 10 onset conditions of words 41-50 used in the current experiment. The data are listed in Table S1.

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Supplemental Figure S8

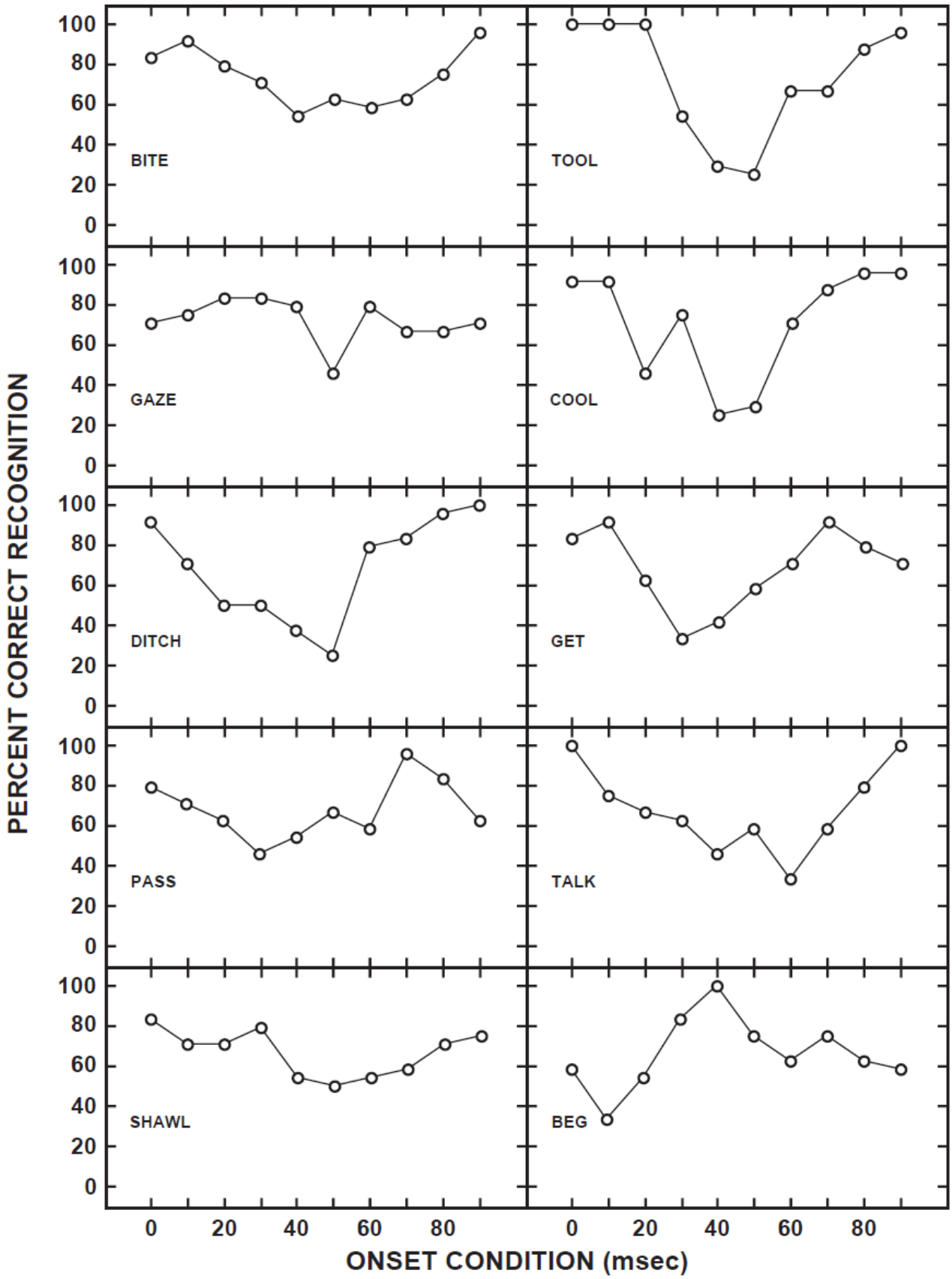

Figure S8. The percent correct recognition for the 10 onset conditions of words 51-60 used in the current experiment. The data are listed in Table S1.

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Supplemental Figure S9

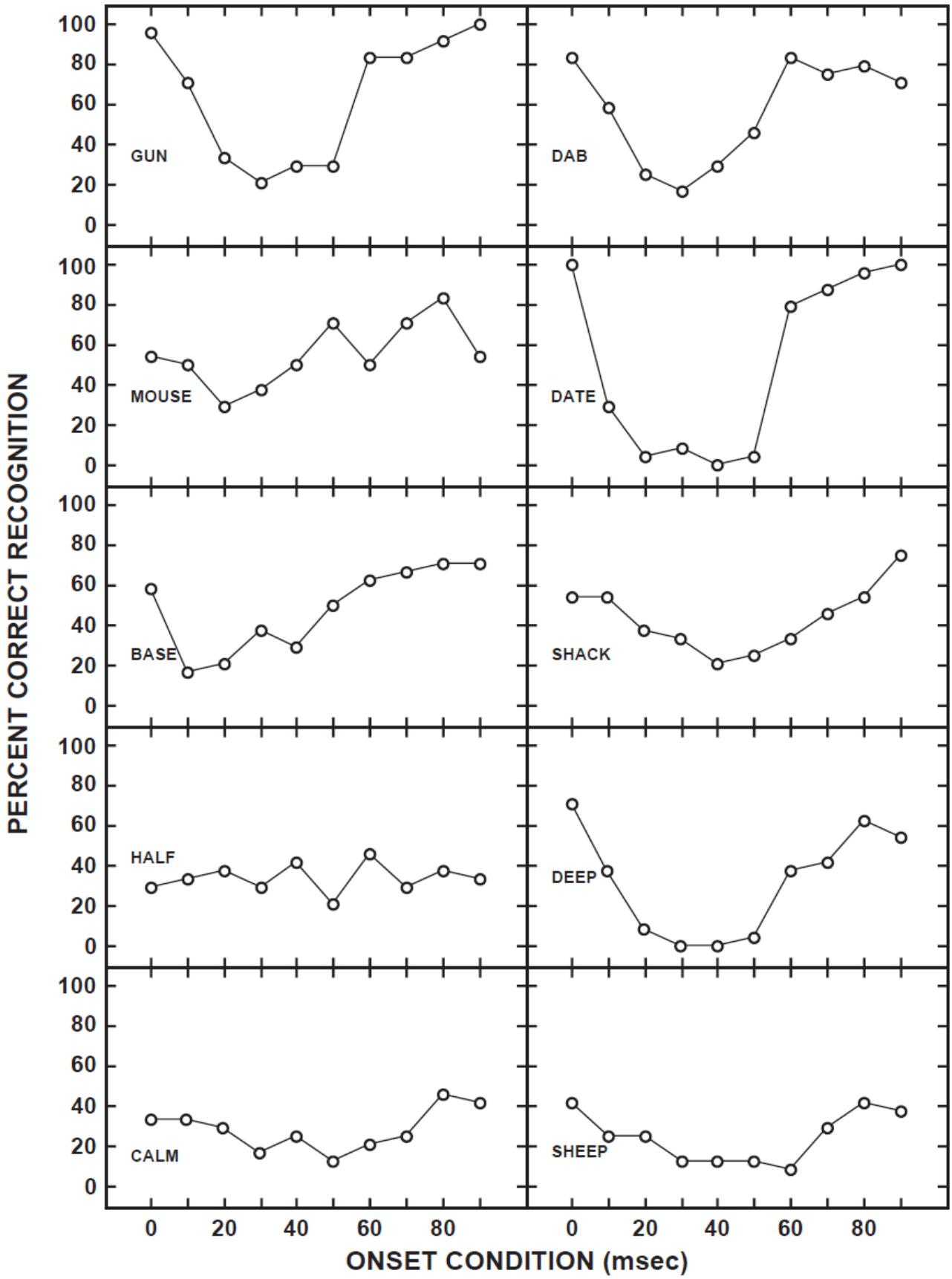

Figure S9. The percent correct recognition for the 10 onset conditions of words 61-70 used in the current experiment. The data are listed in Table S1.

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