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ABSTRACT

Three ten-step series of synthetic speech stimuli were constructed: /raem/ to laem/, /raem/ to /waem/, and /laem/ to /yaem/. Within each series, differences consisted of variations in onset frequency and slope of transition in the second or third formant. These stimuli were presented to 5- to 7-year-old children in identification (picture-pointing) and 3-step same-different discrimination tasks. Two groups of subjects were tested: children having normal articulation, and children who misarticulated /r/ or /l/. Results support the view that some articulation-disordered children exhibit correlated perceptual deficits. (Author)

Perception of /w,r,l,y/ by normally-articulating and misarticulating children[1,2]

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Articulation disorders are rather common among children, but little is known about the etiology of these problems. The group of speech-disordered children whose disorders are not associated with any known organic impairment is a population of interest to speech perception researchers. It has been suggested by several investigators, beginning with Travis and Rasmus in 1931, that these children may misarticulate because they cannot distinguish perceptually among speech sounds. Until recently, studies examining the relationship between perceptual abilities and speech disorders have yielded inconsistent results due to several factors including: 1) use of general perceptual testing rather than error-specific testing, and 2) variability in the means of presentation and type of testing materials. The study to be reported here circumvented these difficulties by employing synthetic speech stimuli to test perception of the approximants /w,r,l,y/ in normally-speaking children and in children who misarticulate the /r/ and/or /l/ sounds. Among the class of approximants, /w/ and /y/ are acquired early (typically by age 3); /r/ and /l/, however, are in general established later. The sounds /w/ and /y/ are often substituted for /r/ and /l/ by misarticulating children.

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Normally-articulating and misarticulating children ranging in age from 5 years 3 months to 8 years 4 months were tested on three synthetic series containing /w/, /r/, /l/, and /y/ in word-initial position. Stimuli were made on the OVE 3C synthesizer at Haskins Labs, using the voice of an adult female speaker. Series went from /ræm/ to /læm/, /ræm/ to /wæm/, and /læm/ to /yæm/. Figure 1 shows a schematization of the /ræm/ to /læm/ series. The ten stimuli varied in onset frequency and slope of transition of the third formant, while the initial portions of F2 were fixed in midrange. The second series, /ræm/ to /wæm/, is shown in Figure 2. In this series, onset and transition of the second formant varied in ten steps while the third formant remained fixed in a low position. The third series, /læm/ to /yæm/, is displayed in Figure 3. Onset frequency and transition rate of the second formant varied in these ten tokens while the third formant remained fixed in a high position. The stimuli in all three series shared a common first formant, pitch contour, and amplitude contour.

Following articulation and audiometric screening and vocabulary testing, sixteen children were tested on identification and discrimination tasks for all three series. Eight of the children had normal articulation, and eight had difficulty articulating /r/ and/or /l/. Three of the misarticulating children had multiple articulation disorders; they had difficulty with three or more sounds in addition to /r/ and /l/, particularly /s/, /z/, and other fricatives. The groups of normal and misarticulating children were matched on age.

The identification task consisted of having the child press a button under one picture of a pair corresponding to the presented series. The children were taught to identify the pictures, shown in Figure 4, as "ram," "lamb," "wham," and "yam." Most of the children were tested in their homes, using a testing set-up similar to the one shown in Figure 5. Each child made ten responses to each of the ten stimuli in each series.

The discrimination task required the children to make "same-not the same" responses to pairs of stimuli. A visual pre-training task using colored paper squares of similar hues was used to insure that the children could respond appropriately in a same-different task. In the speech sound discrimination task, each child responded to acoustically identical pairs and to three-step acoustically different pairs in each series. Equal numbers of acoustically "same" and acoustically "different" pairs were presented. Twelve responses were obtained on each of the "different" pairs. Children were paid for participating and also received small rewards such as pennies, balloons or candies after each block of trials. It took an average of five testing sessions conducted on separate days to collect a complete set of data from one child.

Typical data from one child on the /læm/ to /yæm/ series is shown in Figure 6. At the top is percent identification as /l/, then percent "different" responses to different pairs, and percent "different" responses to same pairs. Data from each child was scored on three measures: 1) the non-interpolated fifty-percent crossover point on identification (in this case at approximately item 7), 2) a consistency score taken as the number of stimuli (of ten) identified as a single phoneme 90 to 100 percent of the time, and 3) a discrimination measure based on the expected difference in number of "different" responses to boundary-spanning different pairs versus within-category different pairs. For example, in the data illustrated in Figure 6, the child received a consistency score of 9, because all items except item 7 are consistently heard as either "lamb" or "yam."

Each child's data were examined in terms of these three measures to determine which children exhibited abnormal perception of any of the three series. Children were classed as deviant on the identification measures of crossover point and consistency if their scores fell two or more standard deviations away from the group mean of the sixteen subjects. On the discrimination measure, children were classed as abnormal if their average number of different responses to boundary-spanning pairs was less than or equal to their average number of different responses to within-category pairs.

Abnormalities of one type or another were observed in 4 of the 8 misarticulating children but in none of the normally speaking children. Partial data from two misarticulating children are illustrative of the types of abnormality observed.

Figure 7 displays data from subject B. R., a severely misarticulating child who substituted /y/ for /l/ and /w/ for /r/ in his speech and who did not distinguish between these sounds as normal children did on our tasks. On the /l/-/y/ series, there was no stimulus which he consistently identified as "yam." The mean boundary on this series for the group of children was at 5.8. If we arbitrarily define this child's crossover as occurring at stimulus 9, we can see that the discrimination data do not correspond to the expected pattern. The child discriminated pairs 6-9 and 7-10 no better than any other pair, and showed a very high, non-systematic error rate on the acoustically same pairs.

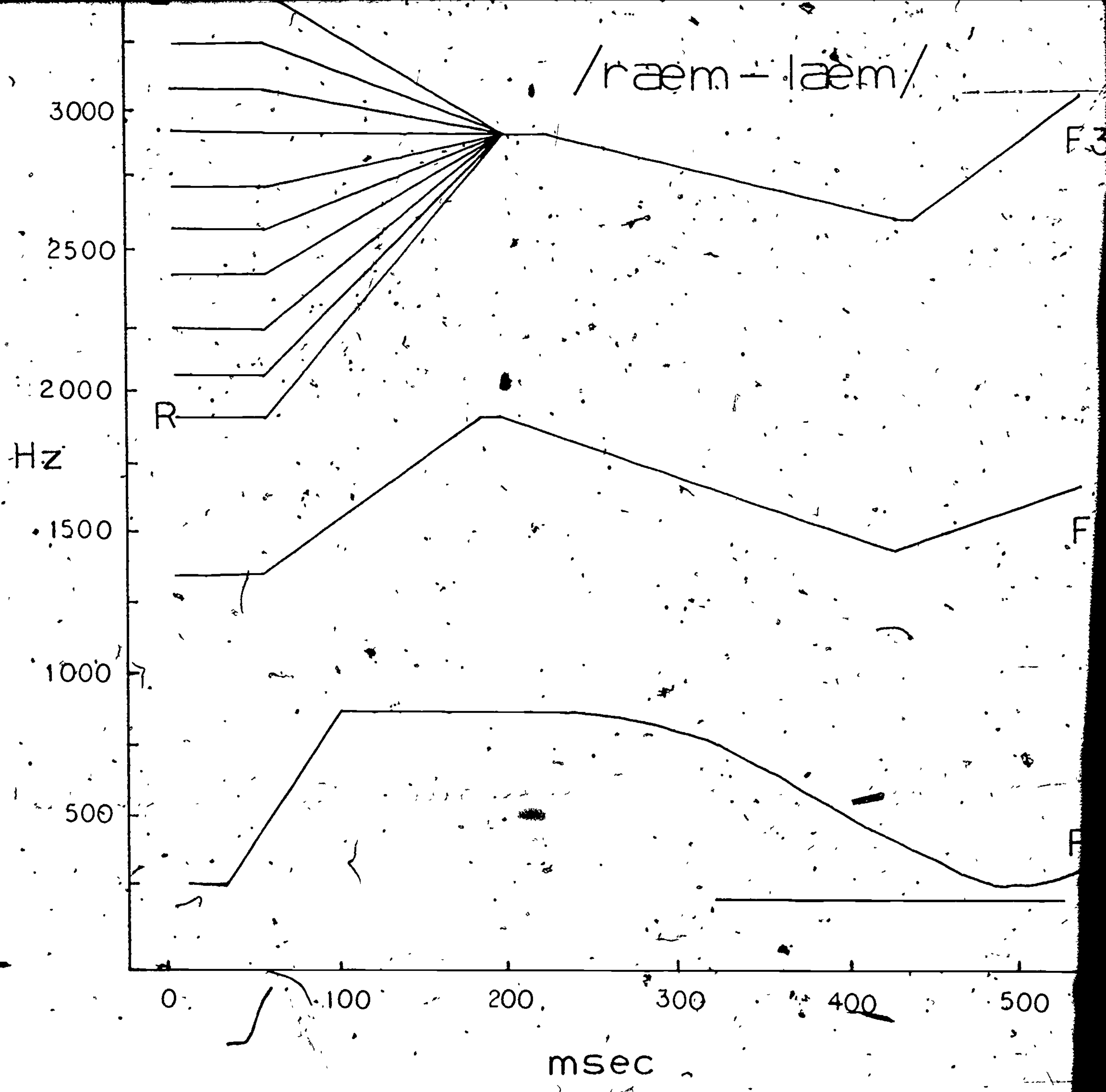
This child showed an even more abnormal pattern on the "wham" to "ram" series as shown in Figure 8. All items were identified as /ræm/ most of the time. However, the few "wham" identifications which did occur all fell on the appropriate end of the series. There is no boundary on this series. The mean boundary for the group was at 7.2. Further, the child's discrimination performance was essentially random.

Data from another child who was classed as abnormal on the consistency measure for the "ram-wham" series is shown in Figure 9. This child also misarticulated several sounds. His productions of /r/ and /l/ were severe distortions of the sounds rather than appearing to be phonemic substitutions, as in B. R.'s case. On this series, he identified only one stimulus with 90% consistency. However, the boundary point is within normal limits.

Data from all of the children are summarized in Figure 10. Misarticulating children are listed in approximate order of the severity of their speech disorder. Asterisks are used to identify children classed as indicating abnormal perception on the basis of our measures. It can be seen that these asterisks are associated only with misarticulating children, and particularly with those having severe articulation disorders.

A few summary observations can be made. First, identification data from normal and mildly misarticulating children suggested that by age 5 or 6 children perceive these word-initial approximants essentially as adults do. Boundary locations and slopes closely resembled those which we obtained from adults in a pilot study. Secondly, some children with articulatory deficits show no perceptual abnormality on these series while others, particularly those who misarticulate other sounds in addition to /r/ and /l/, show abnormalities of one kind or another which bear some correspondence to their patterns of misarticulation.

The implications for speech therapy seem clear. Many clinicians now use perceptual training methods as a matter of course with child clients. Our data suggest that, in the cases of children whose misarticulations involve only the /r/ and /l/ sounds, such perceptual training may be of little use, and the clinician's time might be better spent in more direct training of production. Other children, however, may benefit from perceptual training. Given the diverse types of abnormalities observed in different children, different methods of perceptual training may be required to most effectively help different children. Our data do not speak directly to the question of the utility of perceptual training, but we hope in the future to conduct studies which will address this issue.


/ræm - læm/
3000
2500
2000
R
Hz
1500
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100
200
300
400
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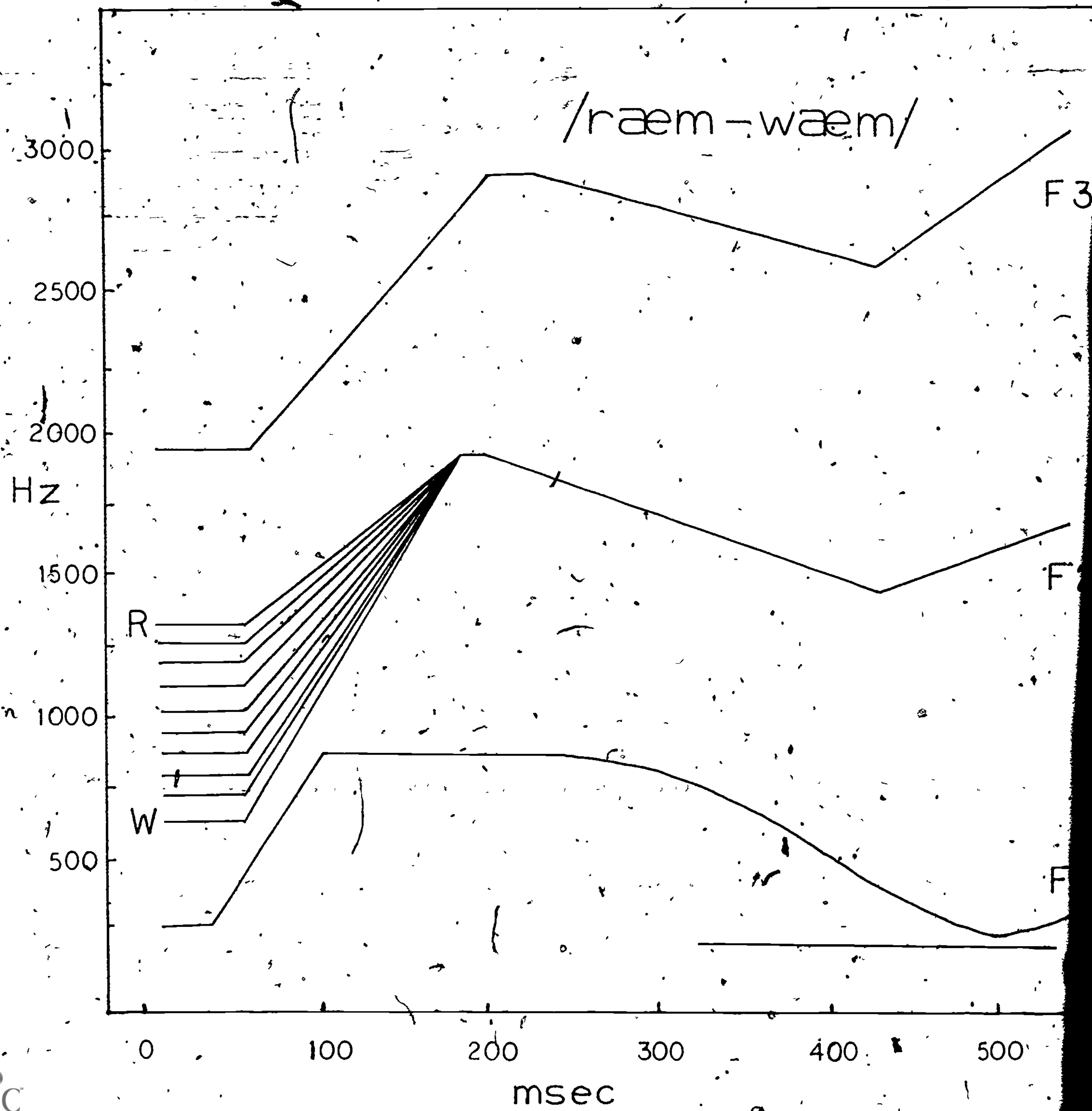
F3
F
F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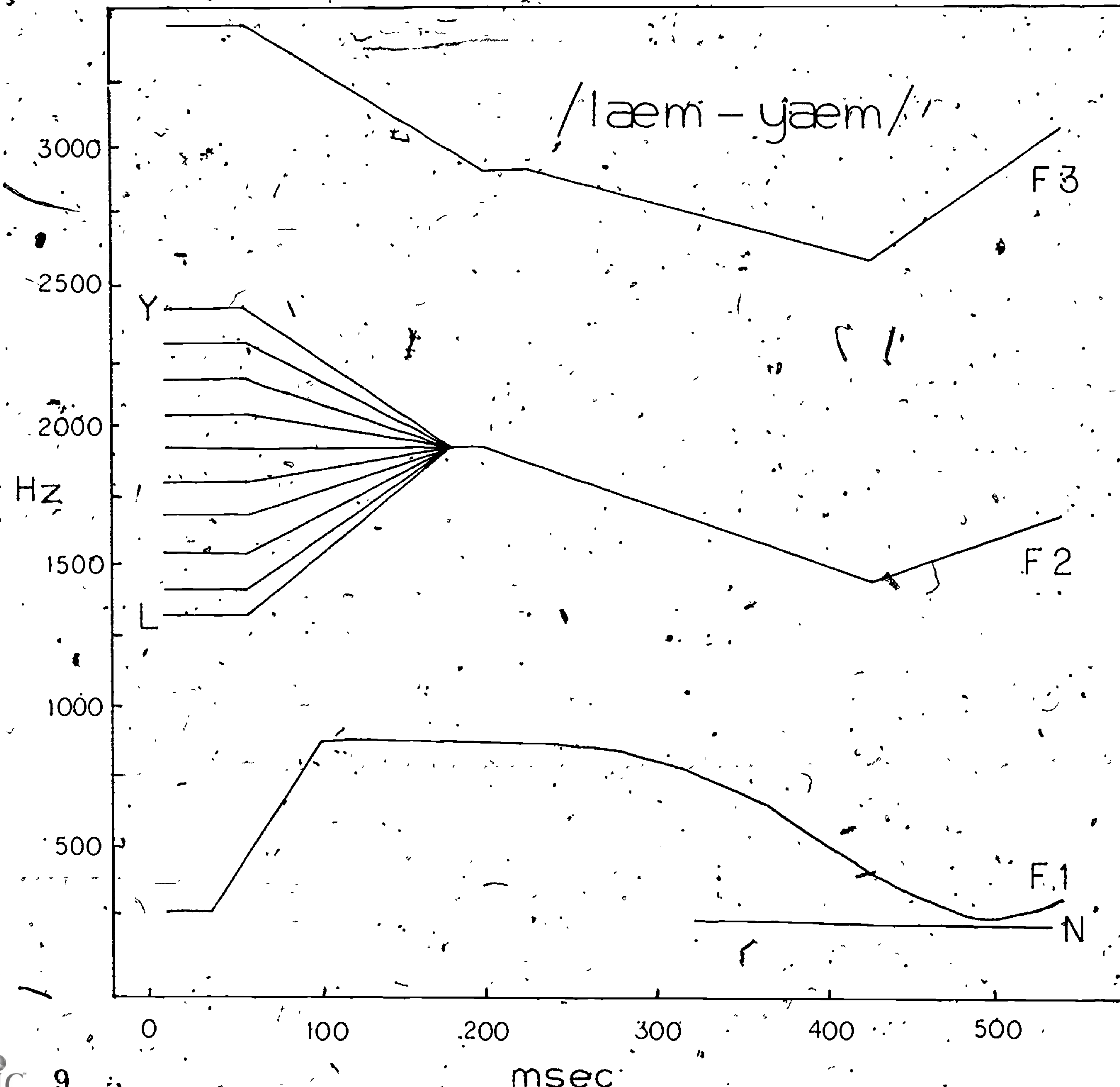

/læm - yæm/
F3
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3000
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500
msec

Figure 3.

Figure 4. Pictures used in identification tests.

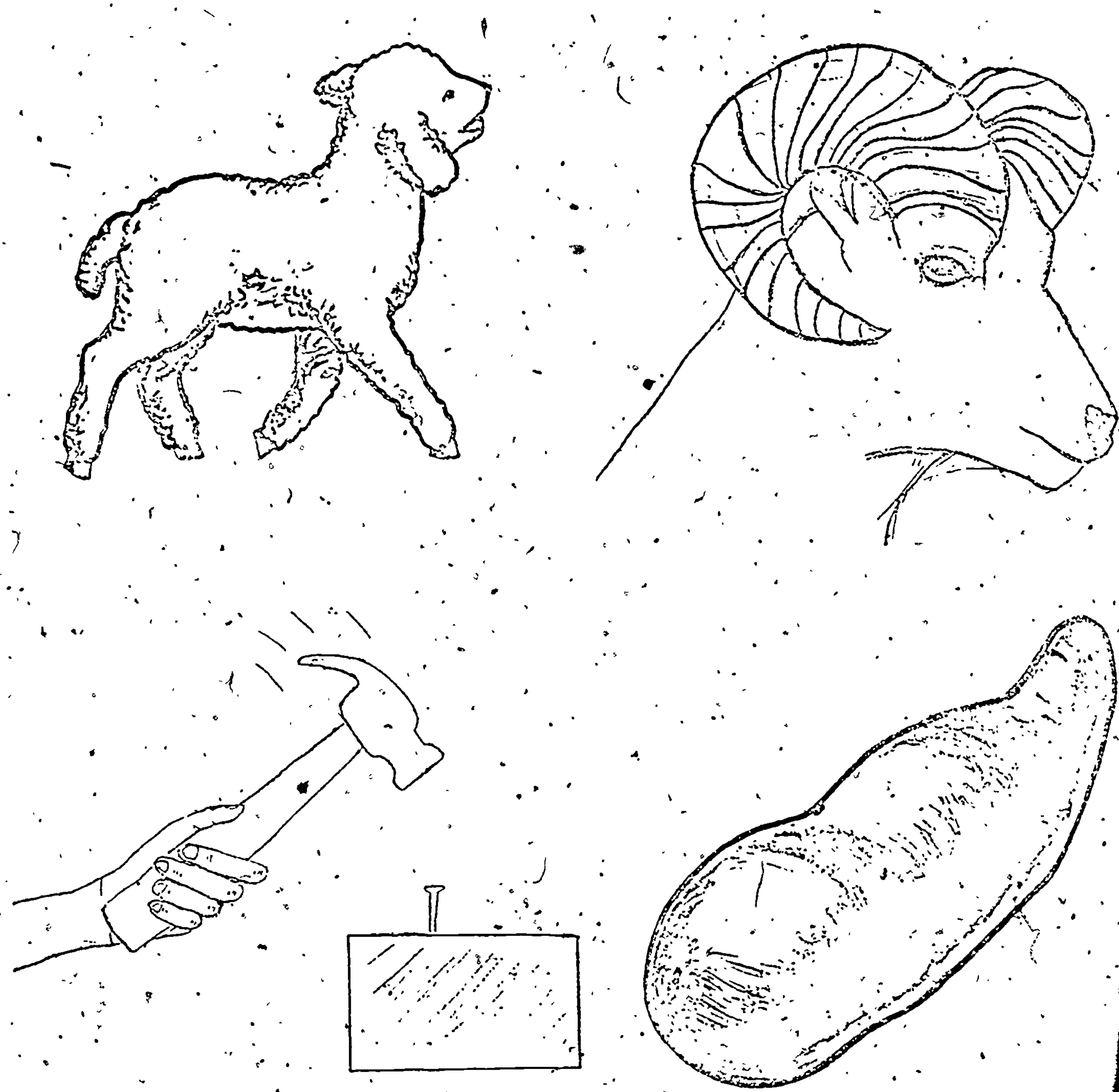
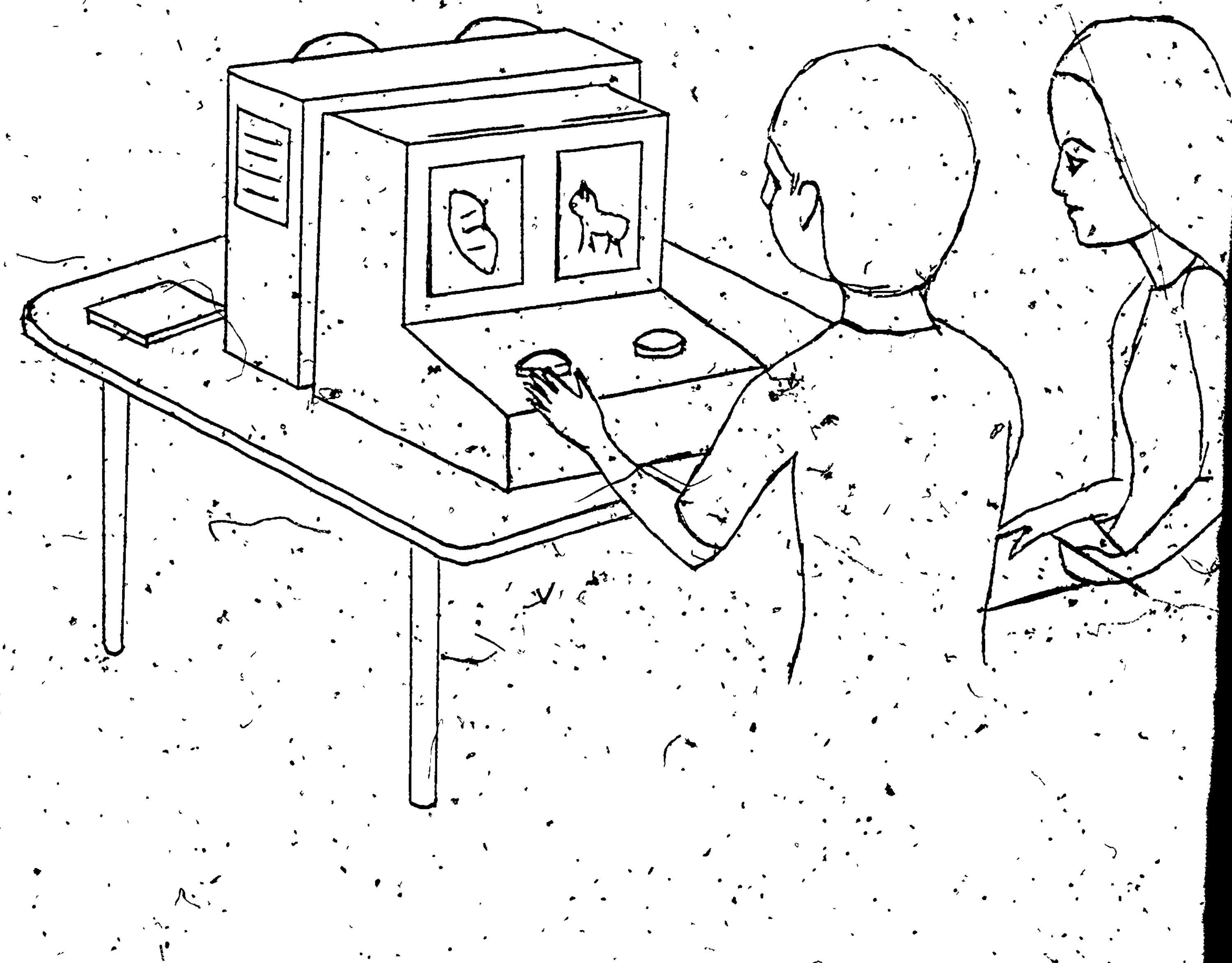


Figure 5. Identification test apparatus.



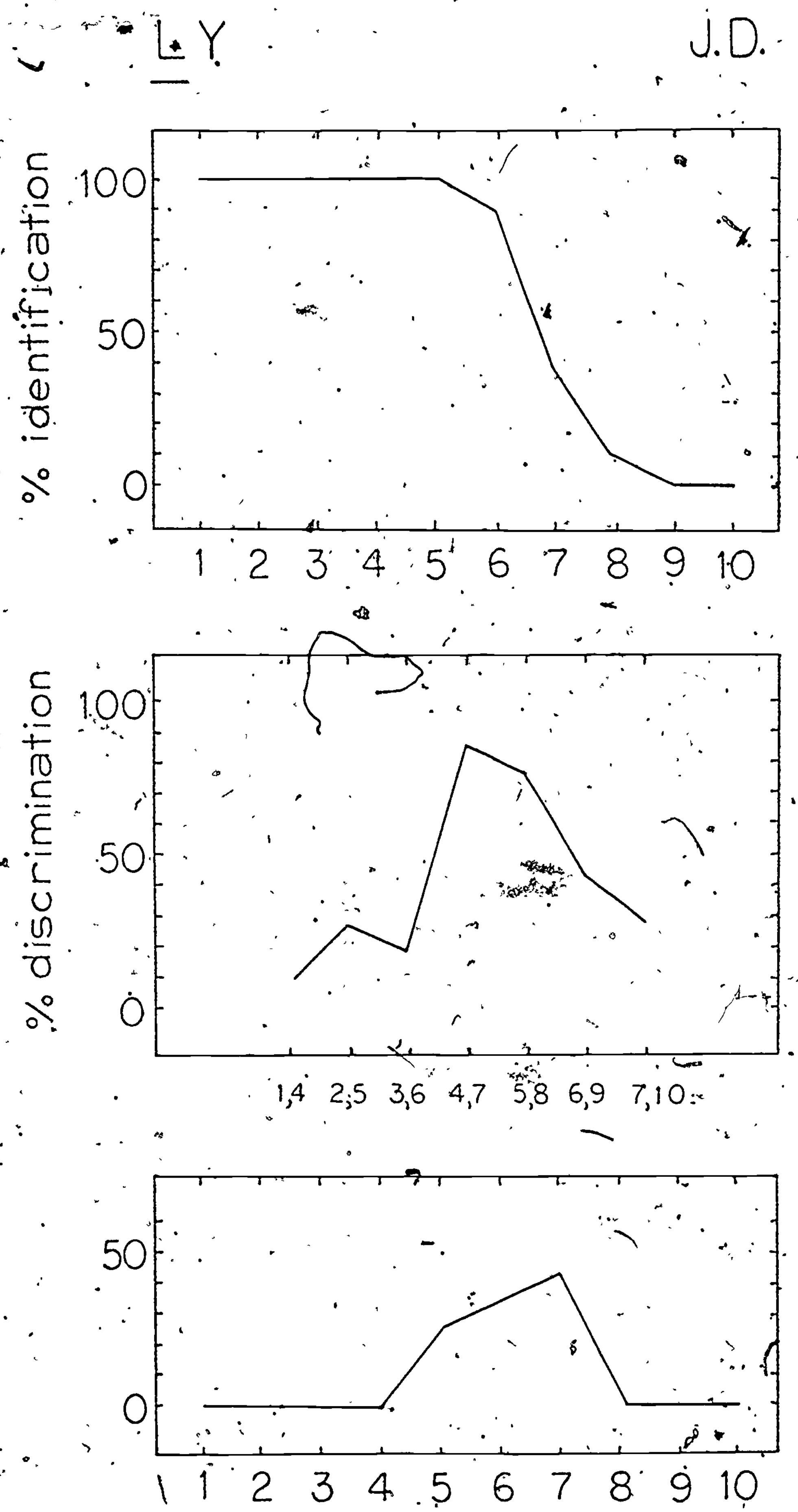

L.Y
J.D.
% identification
100
50
0
1 2 3 4 5 6 7 8 9 10
% discrimination
100
50
0
1,4 2,5 3,6 4,7 5,8 6,9 7,10
50
0
1 2 3 4 5 6 7 8 9 10

Figure 6.

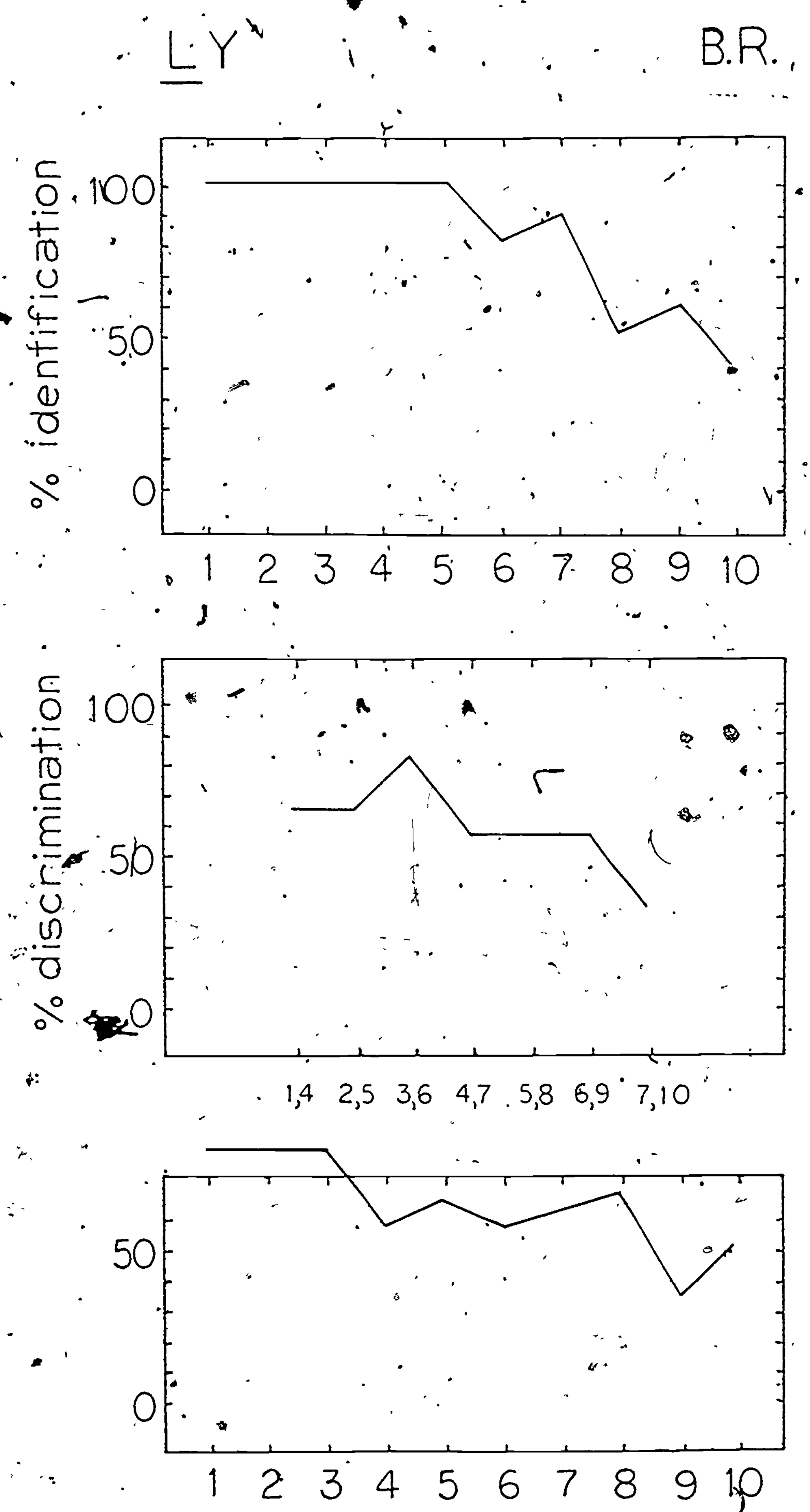

LY
B.R.
% identification
100
50
0
1 2 3 4 5 6 7 8 9 10
% discrimination
100
50
0
1,4 2,5 3,6 4,7 5,8 6,9 7,10
50
0
1 2 3 4 5 6 7 8 9 10

Figure 7.

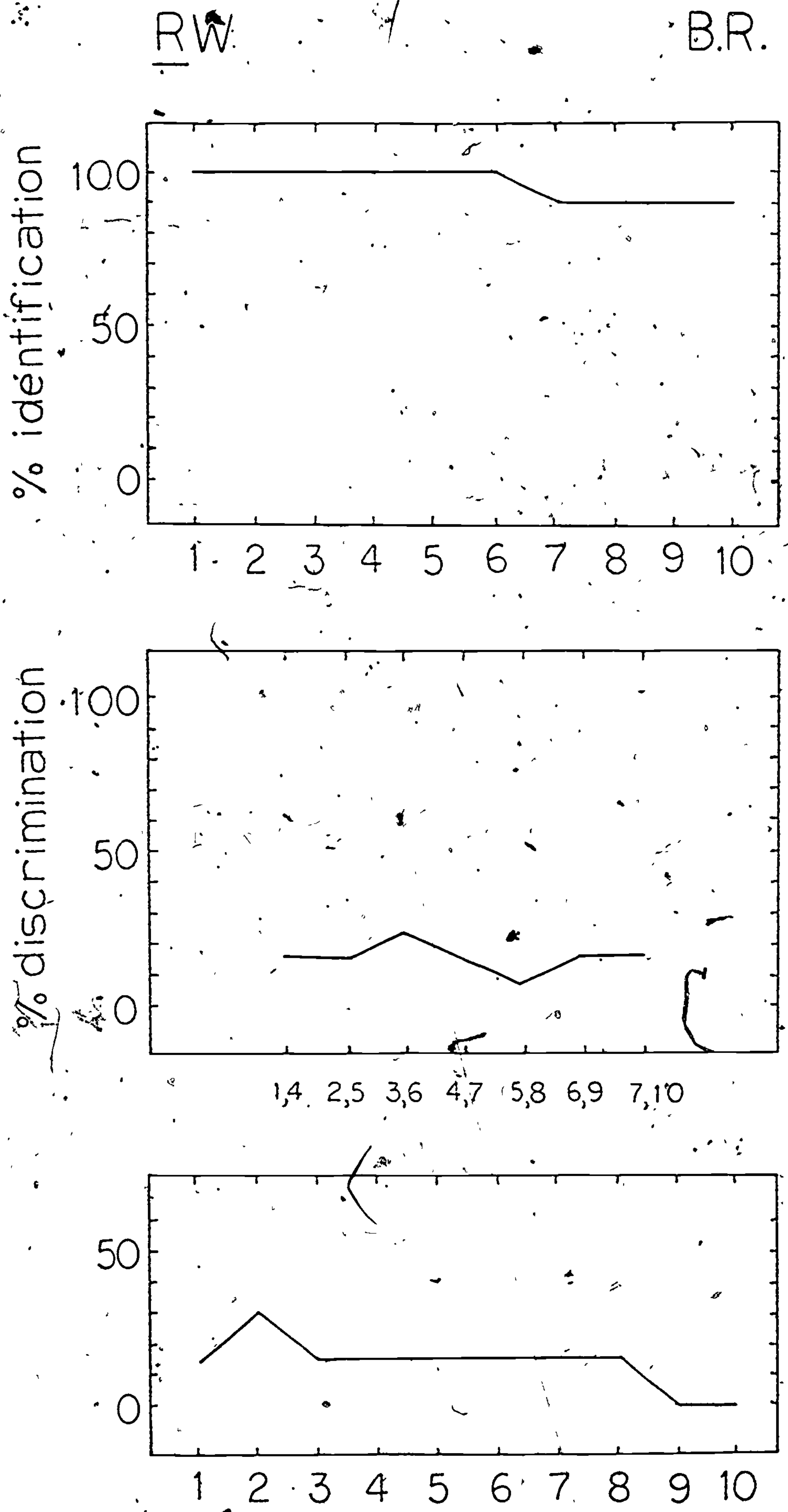

RW
B.R.
% identification
100
50
0
1 2 3 4 5 6 7 8 9 10
% discrimination
100
50
0
1,4 2,5 3,6 4,7 5,8 6,9 7,10
50
0
1 2 3 4 5 6 7 8 9 10

Figure 8.

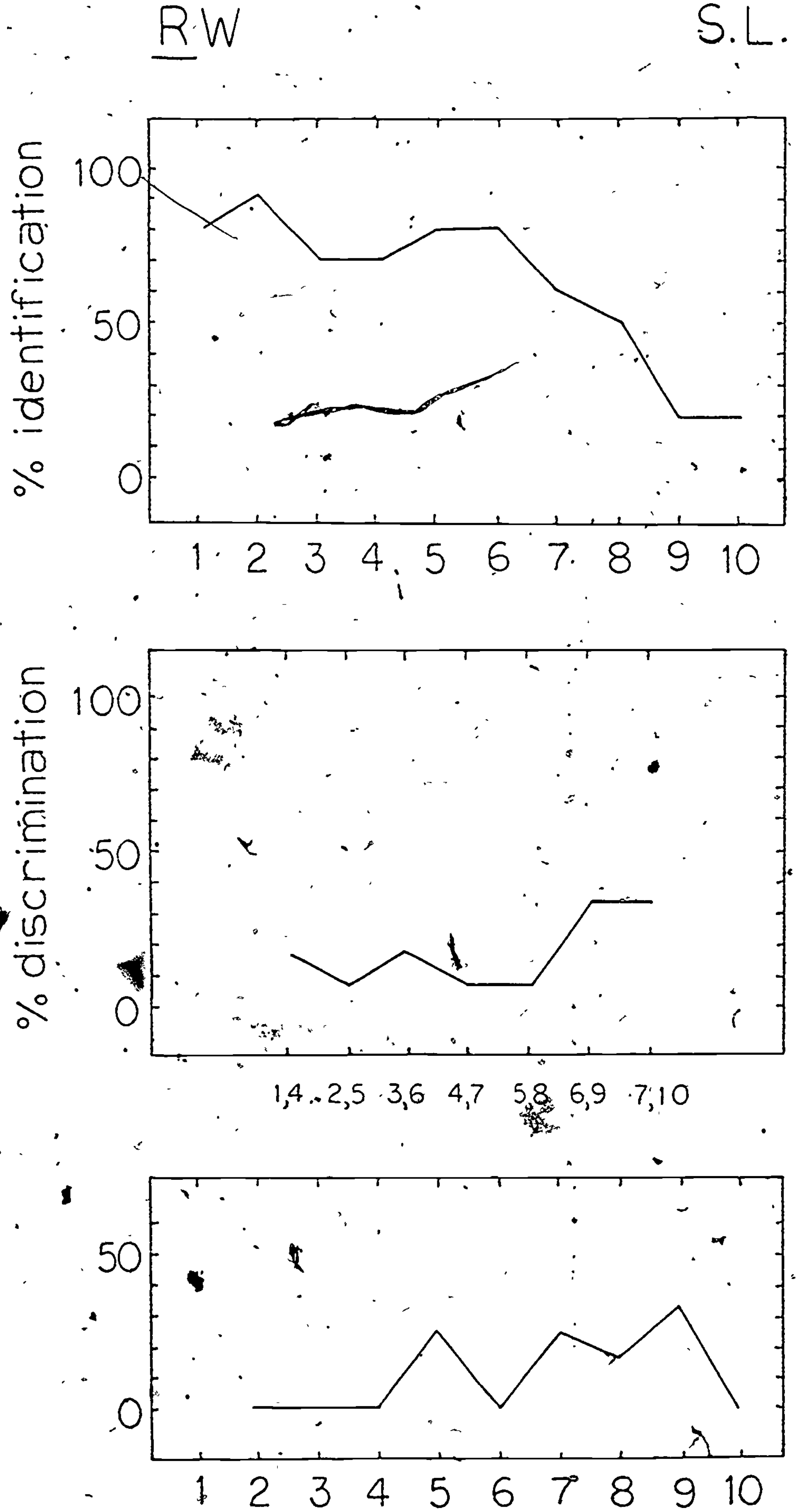

RW
S.L.
% identification
100
50
0
1 2 3 4 5 6 7 8 9 10
% discrimination
100
50
0
1,4 2,5 3,6 4,7 5,8 6,9 7,10
50
0
1 2 3 4 5 6 7 8 9 10

Figure 9.

Figure 10. Indications of Abnormal Perception of /w, r, l, y/

Subjects (Age range: 5:3 to 8:4)	Identification Boundary R/L	Identification Boundary W/R	Identification Boundary L/Y	Consistency of ID R/L	Consistency of ID W/R	Consistency of ID L/Y	Discrimination (3 Step) R/L	Discrimination (3 Step) W/R	Discrimination (3 Step) L/Y
Normal Articulation									
S.B.									
R.D.									
A.J.									
L.O.									
G.P.									
C.R.									
Ka.R.									
A.T.									
Articulation-Disordered: Mild Disorder									
J.D. (w/r)									
J.K. (w/r)									
P.H. (distorted r, s, z)									
Ke.R. (w/r, distorted r)									
D.B. (w/r, w/l)								*	*
Articulation-Disordered: Multiple Disorder									
J.R. (w/r, r/l + multiple other)					*		*		
S.L. (w/r, r/l + multiple other)					*				
B.R. (w/r, y/l + multiple other)		*	*	*			*	*	*