of experimental treatments and age. Analyses of these data revealed that the magnitude of recovery for the 20D condition was reliably greater than that for the 20S condition ($P < .01$). In addition, the 20D condition showed a greater rate of responding than did the control condition ($P < .01$), while the difference between the 20S and control conditions failed to attain the .05 level of significance.

In summary, the results strongly indicate that infants as young as 1 month of age are not only responsive to speech sounds and able to make fine discriminations but are also perceiving speech sounds along the voicing continuum in a manner approximating categorical perception, the manner in which adults perceive these same sounds. Another way of stating this effect is that infants are able to sort acoustic variations of adult phonemes into categories with relatively limited exposure to speech, as well as with virtually no experience in producing these same sounds and certainly with little, if any, differential reinforcement for this form of behavior. The implication of these findings is that the means by which the categorical perception of speech, that is, perception in a linguistic mode, is accomplished may well be part of the biological makeup of the organism and, moreover, that these means must be operative at an unexpectedly early age.

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Randomization and the Draft Lottery

Abstract. Fifty "random permutations" were prepared for use by the Selective Service System as a basis for a two-stage randomization that preceded the lottery drawing on 1 July 1970. This report identifies the permutations used. It also gives the orders in which calendar dates and numbers were put into and drawn from two drums and the correlations between them.

The Selective Service System asked the National Bureau of Standards (NBS) to prepare 25 "random calendars" and 25 "random permutations" of the numbers 1 to 365 for use in connection with preparations for the draft lottery conducted on 1 July 1970, which determined the order in which men born in 1951 would be called for induction into military service (*1*).

In order that all details of the preparations be reproducible, the permutations were drawn from published tables [tables 8 and 9 in (*2*), pp. 152–229]. Table 8 contains 38 permutations of the numbers 1 to 500; by omitting numbers greater than 365, 38 permutations of the numbers 1 to 365 were formed. Table 9 contains 20 permutations of the numbers 1 to 1000; by considering numbers from 1 to 365 and those from 501 to 865, 40 permutations of the numbers 1 to 365 were formed. An assortment of tests for randomness

Table 1. Coefficients of correlation (r) and their significance levels (P) for pairs of permutations used in and produced by the draft lottery procedures. I, Calendar dates and ranks in the order loaded into capsules; permutations 53 and 43, respectively. II, Calendar dates (ranks) in the order of entry into drum, computed from permutation 53 (43) and permutation 46. III, Calendar dates (ranks) in the order drawn from the drum; permutation shown in Fig. 2 (Fig. 3).

Pair	Calendar dates		Ranks	
	r	P*	r	P*
I–II	.0469	.37	.0706	.18
I–III	−.0493	.35	−.0133	.80
II–III	.0387	.46	−.0573	.27

* Probability that correlation between two random permutations exceeds (in magnitude) the observed value.

1.	NOVEMBER 30	30 NOVEMBER	11/30	334
2.	AUGUST 18	18 AUGUST	8/18	230
3.	APRIL 8	8 APRIL	4/8	98
4.	JUNE 14	14 JUNE	6/14	165
5.	OCTOBER 22	22 OCTOBER	10/22	295
6.	JANUARY 8	8 JANUARY	1/8	8
7.	DECEMBER 12	12 DECEMBER	12/12	346
8.	AUGUST 27	27 AUGUST	8/27	239
9.	SEPTEMBER 20	20 SEPTEMBER	9/20	263
10.	SEPTEMBER 8	8 SEPTEMBER	9/8	251
11.	DECEMBER 31	31 DECEMBER	12/31	365
12.	OCTOBER 13	13 OCTOBER	10/13	286
13.	FEBRUARY 2	2 FEBRUARY	2/2	33
14.	MAY 15	15 MAY	5/15	135
15.	OCTOBER 20	20 OCTOBER	10/20	293
16.	OCTOBER 4	4 OCTOBER	10/4	277
17.	APRIL 16	16 APRIL	4/16	106
18.	NOVEMBER 3	3 NOVEMBER	11/3	307
19.	JUNE 20	20 JUNE	6/20	171
20.	AUGUST 23	23 AUGUST	8/23	235
21.	MAY 3	3 MAY	5/3	123
22.	OCTOBER 9	9 OCTOBER	10/9	282
23.	MAY 2	2 MAY	5/2	122
24.	JUNE 1	1 JUNE	6/1	152

Fig. 1. Part of a random calendar ("calendar number 53") prepared by NBS, that was used for loading dates into capsules, showing the redundant format used for printing. [Derived from pages 204–205 of Moses and Oakford (*2*)]

was performed and the set of permutations was found to be satisfactory (*3*).

Each of the 78 (= 38 + 40) permutations of 1 to 365 was printed in two formats: in numeric form and in calendar form (see Fig. 1 for an example of the latter). The matching permutations and calendars were then numbered 1 through 78 (*3*).

To reduce the 78 permutations and 78 calendars to 25 permutations and 25 (different) calendars, a random permutation of 1 to 78 was used as follows. If the *i*th number of the 1 to 78 permutation was between 1 and 25, the *i*th permutation was selected and the *i*th calendar was excluded; if the *i*th number was between 26 and 50, the *i*th permutation was excluded and the *i*th calendar was selected; and if the *i*th number was between 51 and 78, both the *i*th permutation and the *i*th calendar were excluded.

Once all the numbering conventions (*3*) were established, the final selection was strictly determined by the selection of a permutation of 1 to 78. Three dice were thrown by a panel of advisers to the NBS (*4*) and the outcome was recorded and signed. This led to selection [from the $6 \times 6 \times 6 = 216$ permutations of 1 to 100 in Moses and Oakford, table 6 in (*2*)] of the fourth permutation on page 110 (*2*), which was used with numbers 79 to 100 deleted. The chosen 25 calendars and 25 permutations were sealed in unmarked envelopes; each set was shuffled and labeled (calendar or permutation).

At this point, the official task of the NBS statisticians had been completed. In the remainder of this report, we furnish data obtained by us as observers of proceedings conducted by the Selective Service System on 29 June and 1 July.

On 29 June, an official lottery witness picked one of the 25 sealed envelopes containing calendars; the calendar chosen was number 53 (of the original 78) and was the first permutation derived from Moses and Oakford pages 204–205 (see Fig. 1). The dates of the year were then placed in capsules according to this calendar sequence.

Similarly, one of the 25 permutations—permutation number 43—was chosen; this was the first permutation derived from Moses and Oakford pages 194–195. The numbers or "ranks" 1 to 365 were placed in capsules according to this permutation sequence.

A second permutation was chosen from the remaining 24; it was number 46 and was the second permutation (based on numbers 501 to 865) derived from Moses and Oakford pages 196–197. The calendar capsules and the rank capsules were physically placed in two drums according to this second permutation sequence.

On 1 July the drum containing calendar dates was rotated for an hour and the drum containing ranks, whose rotating mechanism malfunctioned, was rotated for a half hour. Figures 2 and 3 show the order in which dates and ranks, respectively, were drawn from the two drums (*5*). The final lottery sequence, which was published in most U.S. daily newspapers, was established by associating the dates with the corresponding ranks (date 259 = 16 Sep-

259	117	18	294	276	193	94	283	124	230	190	243	85	279	346
52	145	148	38	200	87	153	30	70	187	86	97	7	129	253
224	90	20	323	13	154	158	205	56	281	312	104	120	308	337
147	326	134	242	95	217	116	6	360	277	328	98	69	295	8
223	282	168	235	306	265	50	204	12	319	27	280	24	14	22
105	220	305	19	119	125	334	60	298	222	307	236	110	273	338
76	36	75	241	195	101	208	91	173	46	216	252	342	324	271
84	79	189	344	301	64	345	63	103	17	180	100	186	81	150
131	246	1	231	314	42	89	249	202	146	321	58	272	16	191
96	274	226	78	130	192	37	350	72	108	99	365	172	182	264
149	112	57	54	309	83	251	55	238	221	257	49	214	144	88
343	80	156	215	211	21	268	198	174	133	203	303	74	61	330
121	206	297	28	201	304	48	336	284	179	278	65	161	160	296
111	4	287	41	290	9	170	316	320	250	299	140	209	115	322
213	178	325	356	181	32	261	329	15	285	188	196	228	128	315
318	302	335	260	363	163	194	113	310	40	143	106	219	136	102
45	313	71	107	66	137	43	240	331	291	157	347	332	176	3
109	31	123	317	122	2	25	171	169	210	353	357	300	348	183
270	311	23	239	152	139	233	5	218	286	351	237	232	355	288
266	254	340	177	33	141	26	135	267	245	358	151	229	73	225
167	92	11	275	197	352	212	361	126	159	59	44	67	35	263
227	341	162	118	51	39	155	114	138	327	349	199	244	258	47
354	364	165	164	333	184	256	166	185	292	93	293	82	269	175
132	262	289	62	234	29	362	34	10	248	207	77	127	255	142
247	359	68	339	53										

Fig. 2. Calendar days as they were drawn from the drum. Permutation of 1 to 365 corresponding to the order in which dates were drawn during the 1 July lottery. Ordinal numbers of the days of the year were used for computations and are given here for brevity instead of dates. Read by rows.

139	235	185	5	134	257	37	160	240	109	1	275	121	78	19
213	26	9	25	316	95	304	112	317	164	254	142	159	357	130
320	38	211	252	330	135	169	360	325	45	119	202	358	39	110
122	253	40	167	124	64	137	285	80	266	81	267	150	36	116
230	302	289	10	205	88	331	172	152	362	173	131	177	71	132
182	49	243	188	111	301	67	14	17	359	294	274	118	18	305
220	97	258	32	156	178	85	224	307	201	300	313	323	98	309
298	170	106	204	28	299	73	117	143	54	154	165	287	269	209
293	183	133	83	63	227	56	21	356	148	6	66	303	136	158
312	306	103	189	146	174	16	41	241	138	223	126	113	104	68
61	256	86	351	286	203	108	226	91	125	247	337	102	22	147
114	246	233	279	15	129	107	341	44	353	282	332	157	77	52
179	3	149	346	120	311	345	321	84	215	166	296	76	352	339
8	99	115	46	290	53	163	255	197	265	184	242	190	328	280
326	55	35	194	217	335	333	23	75	70	365	273	329	105	123
11	259	347	200	145	51	349	292	245	187	222	31	263	175	89
260	176	24	264	141	212	262	248	168	340	153	151	324	327	336
62	60	171	272	96	195	57	43	214	4	249	219	318	348	322
338	72	48	232	65	155	50	33	251	92	315	364	69	181	310
206	288	198	308	354	225	140	344	237	161	2	350	343	12	58
229	216	144	191	284	208	221	239	268	7	234	13	79	94	261
270	162	355	82	20	127	42	244	180	193	87	90	283	291	334
218	192	363	342	100	30	238	276	59	74	297	196	281	93	236
210	228	34	207	250	277	128	186	101	295	47	319	29	314	199
231	361	278	27	271										

Fig. 3. Permutation of 1 to 365 formed by the order in which ranks were drawn from the drum during the 1 July lottery. Read by rows.

tember with rank 139, 117 = 27 April with 235, and so on).

One measure of the effectiveness of the mixing achieved by rotation of the drums is given by the (rank) correlations between the permutations used for loading the drums and the permutations (Figs. 2 and 3) drawn out. These are shown in Table 1. By this criterion, mixing appears to have been successful.

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2. L. E. Moses and R. V. Oakford, *Tables of Random Permutations* (Stanford Univ. Press, Stanford, Calif., 1963).
3. A detailed report on these randomness tests, and the precise details of numbering conventions, are included in a report in preparation.
4. Dr. A. H. Bowker, chancellor, City University of New York; Dr. Morris H. Hansen, Westat Research Inc., Bethesda, Md.; and Professor Frederick F. Stephan, Department of Statistics, Princeton University.
5. From lists recorded by the authors. See also the *Evening Star*, Washington, D.C., 1 July 1970.
6. We thank Joseph M. Cameron and Churchill Eisenhart for advice and counsel, and our colleagues in the Statistical Engineering Laboratory for assistance in checking computations.

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Scanpaths in Eye Movements during Pattern Perception

Abstract. *Subjects learned and recognized patterns which were marginally visible, requiring them to fixate directly each feature to which they wished to attend. Fixed "scanpaths," specific to subject and pattern, appeared in their saccadic eye movements, both intermittently during learning and in initial eye movements during recognition. A proposed theory of pattern perception explains these results.*

There is increasing theoretical indication, and supporting experimental evidence, that pattern recognition is a serial operation in which the brain processes the pattern feature by feature (*1–4*), at least with patterns that are not overly simple and well known (*5*). In this may be seen the influence on work in visual perception of the current activity in computer pattern recognition and, in broader terms, the increasingly fruitful interaction between brain research and computer and information sciences. If pattern recognition by humans is a serial operation, it is of interest to investigate the order in which features are processed. Normally this processing is largely internal and beyond investigation, but if patterns are presented to a subject under conditions of poor visibility, so that he is forced to look directly (foveally) at each feature to which he wishes to attend, then the position of his eyes will reveal the features processed and his saccadic eye movements from feature to feature will reveal the order of processing. Of course, these experimental conditions force the subject to view the pattern serially, thus prejudging the question of whether recognition is normally serial or parallel, but we preferred to assume that processing is serial (though normally executed internally perhaps, not externalized as eye movements) and to investigate instead the order of processing, as indicated by the path followed by the subject's eye from feature to feature. We have studied these eye-movement paths and have found in them certain regularities that have interesting implications for pattern preception theory.

Our subjects were college students, one male and three female. They were told that their "visual processes" would be studied while they viewed some pictures, which they were to "simply observe." The experiment had two phases, designated as "learning" and "recognition," although these terms were not used in briefing the subjects. In the learning phase the subject viewed five patterns, which he had not previously seen, for 20 seconds each. In the recognition phase, which followed immediately, these patterns were intermixed with five other patterns, to make the recognition process less easy, and the set of ten patterns was presented to the subject three times, in random order which changed each time, each view of each pattern lasting 5 seconds. (The designation "recognition phase" is justified by the fact that, when questioned after the experiment, subjects indicated that they easily recognized each of the five patterns with which they had become familiar during the learning phase.) The patterns were presented by rear-projection in a room illuminated normally with the projector lamp voltage reduced to 20 percent of its normal value (*6*), were drawn with thin lines, less than 0.5 mm wide on the screen 60 cm from the subject's eye, and were relatively large, a typical pattern subtending about 20° at the subject's eye. Under these combined conditions of poor visibility the subject, while fixating one extremity of a pattern, could not see any significant details of the opposite extremity. His eye movements during learning and recognition were measured monocularly by means of the diffuse scleral reflection technique (*7*), modified and extended to operate in the vertical as well as the horizontal direction. The equipment calibration was checked at regular intervals during the course of each experiment to ensure consistency. The measured eye movements were recorded on magnetic tape and later played back and plotted on reproductions of the patterns viewed. Playback and plotting were a two-stage process: the eye-movement signals were sampled, digitized, and stored by a digital computer and then reproduced by the computer at about 1/20 of the original rate, thus allowing each fixation to be numbered by hand as it was plotted, to create a permanent record of the order of the fixations.

Analysis of the records obtained showed, first, that when a subject was freely viewing a pattern during the learning phase, his eye usually scanned over it following, intermittently but repeatedly, a fixed path characteristic of that subject viewing that pattern (quite different fixed paths being followed by the subject with different patterns and by different subjects with the same pattern); and second, that when the same pattern was presented to the subject during the recognition phase, his first few eye movements usually followed the same path he had established for that pattern during the learning phase. For example, Fig. 1A shows a typical pattern (*8*) viewed by a subject in these experiments; Fig. 1B is an idealized drawing of the fixed path observed repeatedly in his eye movements; Fig. 1C shows the equipment calibration immediately preceding his learning-phase viewing of this pattern; Fig. 1, D–F, are three extracts from his eye movements during the 20-second learning-phase viewing, showing occurrences of the fixed path (in Fig. 1E very detailed, in Fig. 1F somewhat truncated); and Fig. 1, G–I, show his initial eye movements