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ACOUSTIC CONFUSIONS IN IMMEDIATE MEMORY

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Sequences of 6 letters of the alphabet were visually presented for immediate recall to 387 subjects. Errors showed a systematic relationship to original stimuli. This is held to meet a requirement of the decay theory of immediate memory.

The same letter vocabulary was used in a test in which subjects were required to identify the letters spoken against a white noise background. A highly significant correlation was found between letters which confused in the listening test, and letters which confused in recall.

The role of neurological noise in recall is discussed in relation to these results. It is further argued that information theory is inadequate to explain the memory span, since the nature of the stimulus set, which can be defined quantitatively, as well as the information per item, is likely to be a determining factor.

I. Introduction

One of the accepted hazards of immediate memory experiments, using simple material auditorally presented either from tape recordings or 'live', is the possibility that subjects have not correctly heard the stimuli. One tries to minimize this by speaking clearly, using efficient equipment, and by generally optimizing listening conditions. The amount of error then found which is likely to be perceptual rather than recall will almost certainly be relatively quite small. If one is merely concerned with error quantitatively, it will hardly matter. But if for some reason the nature of specific errors is of concern, then it is possible that perceptual errors may introduce into the results a systematic bias which would be difficult to distinguish from systematic recall errors.

There is at present little evidence available on the likelihood and character of perceptual confusion of letters or digits spoken in the kind of good listening conditions usual in immediate memory experiments. Moser & Fotheringham (l960) present a confusion matrix for spoken digits, but spoken against sufficient white noise to produce 60% errors. Curry, Kay &, Hutton (1960)) have shown that, in good listening conditions, letters of the alphabet spoken at ordinary sound levels do indeed yield errors of perception. They show that some letters are more intelligible than others, but offer no confusion matrix. There is therefore some experimental support for the statement made in the opening sentence of this paper, But this does not mean that all systematic errors in immediate recall experiments are perceptual—only that they could be.

Now the claims of the decay theory of immediate memory demand the existence of partially decayed memory traces. One would expect that such traces would sometimes yield memories which were not exactly correct, but which were not random with respect to the original stimuli—i.e. not guess. This becomes then a problem of showing that systematic errors occur after the likelihood has been removed that such errors are perceptual. At this stage it hardly matters in which way a persistently recurring error is related to the stimulus it replaces. Nevertheless, two clues help to suggest the kind of test material that might lead to an adequate demonstration. The test is the occurrence of acoustic confusions referred to earlier; these may not be largely perceptual errors after all. The second is common experience of acoustic confusions in Long-term memory (e.g. for names) which Woodworth (1938) noted. For instance, Woodworth recalled azalea as aspasia. It would indeed add point if a mechanism of forgetting common to both long- and short-term memory emerged from this study. The experiment to be reported therefore describes an attempt to demonstrate the presence, in short-term recall, of acoustic confusions which could not easily be attributed to errors of perception. The necessary procedure calls for a two-part investigation. First, a determination of recall confusion occurring with a set of test items visually presented. Secondly, a determination of the perceptual acoustic confusions that occur when listening to the same test items with no memory involved. The point would be made if there was an association between the two sets of confusions. If memory errors were systematic, but the association with listening errors poor, the data would suggest likely associations.

II. METHOD—RECALL

Material

A vocabulary of 10 letters was used. Two groups of letters were sought the spoken names of which (Ay, Bee, See, etc.) had high within-group acoustic confusability, and low between-group confusability. Since there appears to be no suitable published confusion matrix for the intelligibility of spoken letters, the vocabulary was chosen intuitively and tested subsequently. The following letters were used; BCPTVFMNSX.

A set of 120 6-letter sequences was prepared using the above vocabulary, and subdivided into 6 blocks of 20 sequences. The letter order was basically random but with a number of constraints, viz.; no letter occurred more than once in any sequence: within each block of 20 sequences, each of the 10 letters occurred equally often in each serial position, and within each block, every possible diagram (successive letter pair) occurred at least once in each possible serial position.

Thu blocks of sequence were amalgamated into six different pairs of blocks and a test comprised the 40 sequences of these amalgamated blocks of 20. The sequences were photographed, 1 letter per frame, on 16 mm. film, each sequence preceded by three 'ready' frames carrying a spot.

The lettering used came from a standard photographic captioning set, but the legibility after photographing was tested. Slides were made of the appropriate letters and were shown to groups of postmen (aged 20-50) under the following conditions. Letters (white on black) were flashed singly in random order onto a greyish screen. The duration of exposure was l/200th sec. with aperture f 4.5. A medium neutral density filter was interposed between lens and screen. Subjects wrote down each letter as it occurred, guessing if necessary. The viewing conditions of this test were such that the error rate was about 40%. No systematic confusions between letter shapes was found. It was therefore accepted that in the very much better viewing conditions of the main experiment, consistent errors were unlikely to be due to discrimination difficulties.

Procedure

The sequences were visually presented by means of frame by frame 16 mm. film projection. The projector was controlled by an electronic timer pulsing at a rate of 80 per minute. A new letter thus appeared every 0.75 sec. After the sixth letter of a sequence, the experimenter stopped the projector until subjects were ready for the next sequence.

Subjects were 387 trainee telephonists including males and female and aged between 16-50 (Since the results which follow show no effects due to sex or to age, under or over 40, there will be no further discussion of individual differences). They were tested in groups of about 10, each group being given one test as defined above. The six available tests were done by approximately equal number of subjects.

Subjects were instructed to watch the screen for the appearance of the 6 letters, and at the end of the sequence to write it down in the correct order on printed answer sheets. They were told to guess rather than leave blank spaces, and the 10-letter vocabulary was written on a blackboard and hence available for reference throughout the procedure. In this way extra-vocabulary intrusions were almost entirely avoided.

Scoring

Sequences were scored letter by letter. A letter not correct for the particular position in the sequence was scored as wrong, regardless of type of error or any subjective impression on the part of the scorer. Those sequences were extracted for further analysis which had one single letter wrong and no other error. Sequences containing any other kind of error were excluded from subsequent analysis. In this way most of the data returned by the subjects were ignored, and this is why so many subjects were used. But what remained were sufficiently numerous and clearly defined. Sequences retained had only a single substitution error. If the data had not been restricted in this way, it is unlikely that anything other than 'noise' would have been added. A 10 x 10 confusion matrix was set up showing which letters were written as responses to which stimuli.

III. METHOD—AUDITORY CONFUSABILITY

Test items

Each of 10 (untrained) speakers recorded 6 practice letters and then the randomized letters of one alphabet in a conversational manner at a rate of 1 letter every 5 sec. The sound level of the speech signal was continuously monitored, and an (on average) equal amount of white noise added. The white noise formed a continuous background on the tape, but was not of course heard by the speakers during recording. The finished tape was divided into two halves each containing five alphabets spoken by 3 male and 2 female voices.

Test procedure

Three hundred Post Office employees (male and female, aged 16-60) listened to one or other of the two halves of tape. They were instructed to listen carefully for the signal (every 5 sec.) and write down on prepared answer sheets which letter they thought it was. They were told to guess rather than to leave blanks. Subjects were tested in groups of 30. The overall error rate was 61%. A lower rate would have been preferred, but of course if subjects were guessing all the time the rate would have been about 96%. The errors were set up in a 26 x 26 confusion matrix. (The rank order of the intelligibility of the letters was correlated as between (a) the two sets of 5 speakers, (b) male and female listeners, and (c) listeners under and over 35 years of age (sex kept separate). In every case the correlation was significant beyond the 0.001 level.) Clarke (1957) has amply justified the use of deduction about smaller confusion matrices made from a large one. Accordingly the relative acoustic confusability of the 10 test letters was derivable from these data.

IV. RESULTS

The resulting confusion matrix of the auditory confusability test is shown in Table 1. It shows the frequency with which a particular response was made to a particular stimulus letter when the response was incorrect. For general reference, the complete error matrix for the vocabulary alphabet is given as an Appendix.

Inspection confirms that the selection of these ten letters was suitable in that confusions are relatively high within the two groups BCPTV and FMNSX and relatively low between them. It should be remembered that the choice of these 10 letters is quite arbitrary. It is only necessary that there should be some significant confusions amongst them—and this is clearly so. The critical question is whether the letters which confuse in the auditory confusability test, also confuse in short term memory. Table 2 gives the confusion matrix resulting from the memory test for those cases where only a single letter in the sequence was incorrect.

The first point to note is that errors are not random. Inspection indicates that when an error of recall is made, the substituted letter is likely to be one which sounds like the correct letter. A 2 X 2 chi-squared test using the sum of the values in the four quarters of Table 2 shows an association of this kind which is significant beyond the 0.001 level. Another way of looking at the data is to consider each stimulus letter and examine the distribution of recall errors amongst the remaining 9 letters. Chi-squared tests indicate that, in no case can this distribution be considered random. In other words, when a letter cannot be remembered, what the subject records is not determined by chance. Certain systematic substitutions are made, the nature of which was examined in relation to the listening data of Table 1.

Table 1. *Listening confusions*

stimulus letter

Response letter	B	C	P	T	V	F	M	N	S	X
B	.	171	75	84	168	2	11	10	2	2
C	32	.	35	42	20	4	4	5	2	5
P	162	350	.	505	91	11	31	23	5	5
T	143	232	281	.	50	14	12	11	8	5
V	122	61	34	22	.	1	8	11	1	0
F	6	4	2	4	3	.	13	8	336	238
M	10	14	2	3	4	22	.	334	21	9
N	13	21	6	9	20	32	512	.	38	14
S	2	18	2	7	3	488	23	11	.	391
X	1	6	2	2	1	245	2	1	184	.

Table 2. *Recall confusions*

Stimulus letter

Response letter	B	C	P	T	V	F	M	N	S	X
B	.	18	62	5	83	12	9	3	2	0
C	13	.	27	18	55	15	3	12	35	7
P	102	18	.	24	40	15	8	8	7	7
T	30	46	79	.	38	18	14	14	8	10
V	56	32	30	14	.	21	15	11	11	5
F	6	8	14	5	31	.	12	13	131	16
M	12	6	8	5	20	16	.	146	15	5
N	11	7	5	1	19	28	167	.	24	5
S	7	21	11	2	9	37	4	12	.	16
X	3	7	2	2	11	30	10	11	59	.

The association between the two complete sets of confusions was tested by calculating Spearman's coefficient of rank correlation. Considering all 90 cells, a value of +0.64 was obtained. This yields a t value of 7.68 which is significant at beyond the 0.0001 level. This establishes beyond any doubt that even with visual presentation material to be memorized, when recall errors occurred they were similar in nature to hearing errors when the signal was partially masked by white noise.

V. Discussion

Acoustic confusions in recall

It was pointed out in the Introduction that a decaying memory trace ought to be revealed by the presence of errors which bore a systematic relationship to the original stimulus. A conventional memory span test samples the decay curve over the critical period of time when decay is rapid. For a given stimulus, the decaying trace might be expected to yield a different recall response at different points in the decay time-curve. But the decay curve of a given stimulus, always examined at the same point, should lead to consistent erroneous response. Table 2 clearly shows the presence of errors systematic in a manner which would support this analysis.

The Introduction further suggests that errors would be systematically related to stimuli in one particular way; there would be acoustic resemblance. The rank order correlation between Tables 1 and 2 indicates the remarkable similarity between memory errors and listening errors. The confusions reported when listening to noise-masked speech provide a highly reliable prediction of the course of forgetting.

There is of course no mystery in the fact that visually presented memory material should yield acoustically related errors. It merely indicates that the majority of subjects verbalize the stimuli, rather than attempting to store them in visual form. What is interesting is not that the memory distortions correspond to the sound of the original stimuli verbalized, but that they correspond so closely to the distortions occurring when speech sounds are partially masked by white noise. This point will be returned to later.

Indeed the true amount of association must be even higher than that shown. The 'listening' evidence contains a certain amount of random error--both in itself, when subjects have been unable to decide between any of the alternatives, and in its relationship to the 'memory' data. Ideally the association should be tested for each subject individually with his own speech used for the listening task. The small sample of voices used in the listening task would be only an approximate match to any individual voice. These factors would tend to lower the correlation between memory errors and acoustically masked speech.

These results clearly support the functional description of forgetting outlined by Brown (1959) in terms of information theory. For instance, Brown describes decay of a trace as 'a fall in the signal-to-noise ratio'. He vividly illustrates this by an analogy of a letter chalked on a blackboard and increasingly smudged. 'Some smudging.. .will leave it legible: it starts with internal redundancy so that some "decay" does not matter. Further smudging, however, will make it difficult to read....

What an informational model inevitably misses, though, is that during the course of 'smudging', a systematic change in the signal-to-noise ratio will yield systematic output changes. The logic of information theory is such that unless specifically stated, alternative responses are equi-probable. A weakness of an informational mode of forgetting is that in the Brown-type analogy, a letter is legible in spite of some smudging. But when smudging has increased to a point where the letter is no longer correctly legible, all the letters in the stimulus set are equally likely to be reported.

Acoustic confusions and memory span

This logic has led to the extremely important prediction that memory span is a function of the information per item in the stimulus set (Pollack, 1953; Miller, 1956). The present data suggest an alternative prediction.

The facts seem to be that when an item cannot be recalled, the probability of other items in the set being given as response are constant and unequal. Systematically, certain items are more likely to be given than others. In the material being discussed, these probabilities depend on the acoustic similarity between the various items. From this one could argue that the more chance there is of acoustic confusion within the stimulus set, the poorer will recall be. It would follow that the memory span would be a function of the acoustic similarity of the members of the set. The span might depend not on the number of alternative items in the set, but on the number of acoustically similar items in the set. Increasing the size of set might or might not increase the number of acoustically similar items in it.

One can imagine four vocabularies, viz: (1) 2-letter high confusability; *(2)* 2-letter low confusability; (3) 8-letter high confusability; (4) 8-letter low confusability. On an informational basis, one would expect (1) and (2) to yield the same memory span. Also (3) and (4). One would further expect the span for (1) and (2) to be longer than for (3) and (4). But on the basis of the argument above, the size of the spans, taken to be determined by the acoustic similarity in the sets, could well be in the order: (2) (4) (1) (3).

Experimental evidence on the question of vocabulary size and span is conflicting. Miller (1956) quotes unpublished work by Hayes, supporting Pollack's (1963) earlier study, indicating that span is more or less independent of vocabulary size. Hayes used digits, letters and words; Pollack used digits and letters. In neither case are the actual items given which were used for each size of set. Crossman (1960) using a number of ingenious but unusual vocabularies—e.g. black/white, £. s, d. N., S., E., W., etc.—showed the relationship predicted by information theory, Conrad & Hille (1957) using 2-, 4-, and 8-digit vocabularies found the opposite to Crossman, that the larger the vocabulary the better the span.

Without knowing the exact sets used by Hayes and by Pollack, their result cannot be discussed in terms of confusability. Crossman's could if the acoustic relationships were estimated and if other things were equal between the vocabularies he used. In the case of Conrad & Hille, it is notable that the 2-digit set used the digits 2 and 3, the 4-digit: 2, 3, 4, 5, and the 8-digit: *2,* 3, 4, 5, 6, 7, 8, 9. Moser & Fotheringham (1960) have shown that the two digits most likely to confuse acoustically are in fact 2 and 3. Additional digits are likely to make the set in entirety less acoustically confusing, and would on the present argument lead to longer spans. It may be that Miller's colourful statement about the magical number 7, is, for the memory case, right but for the wrong reason. Whether seven items minus or plus two can be recalled may depend not on vocabulary size, but on the nature of the items used in each stimulus set.

Present results lead to the general prediction that memory span is a function of the number of acoustic confusions expected from the vocabulary items used. The expected value depends on the probability with which any item confuses with any other. Strictly, of course, the word confusion here refers to recall confusion whether acoustic or any other. In this case, prediction of the span for a given vocabulary is not possible until after the event when the confusion probabilities are known. But because of the special relationship between the data in Tables 1 and 2, and because therefore Table 1 gives approximate estimates of the probability of recall confusion for alpha vocabularies, the appropriate prediction could in principle be made and the model specifically tested. The next section will discuss this unique relationship between acoustic confusions in listening and confusions in recall.

The role of neurological noise in memory

Brown (1959), more than anyone, has developed the concept of noise as a determinant of forgetting. He equates decay of a memory trace with 'decrease in the signal-to-noise ratio'. In his use of the term noise, Brown is thinking of an information theory model where the noise concept is necessary to account for the discrepancy between input and output. Brown specifically is not thinking of noise as having any physiological correlate. In the information theory sense, the presence of noise will ensure degradation of the signal, but the way in which Brown's functional model is formulated precludes any specification of the degradation. The present experiment has demonstrated a highly specific and consistent distortion of signal. One must therefore suppose the presence of a specific type of noise which is random with respect to the specific nature of the memory trace. Neurological noise might very well meet the requirement.

Hebb (1961) writes: 'Any random activity in these excess neurones (the ones not needed for the task being learned) is "noise ", which must tend to interfere with the learning.' In the same Symposium, Eccles (1961) says that 'if there is electrical interaction. . .everywhere in the nervous system, then everything should be electrically interacted with everything else. I think this is only electrical background noise. . . I would say that there is electrical interaction, but it is just a noise, a nuisance.'

Two postulates emerge from this: (1) a pattern of neural activity distorted by neural noise; (2) because of the relationship between Table 1 and Table 2, a form of neural storage which preserves directly definable aspects of the physical stimulus. Memory errors are thus seen to be related to the signal-noise ratio prevailing at the time of recall. That the ratio will change is highly likely. But the question whether this is through decrease in signal strength or increase in noise suggests some speculations which may be worth following.

The extremely rapid rate of forgetting in the absence of rehearsal is now accepted. Fairly quickly (in a matter of seconds) the pattern of specific neural activity will dissipate until it is no longer discriminable from the continuous random neural activity which constitutes neurological noise. The memory trace is irrecoverably lost. But many memories have a more permanent neural basis, an inescapable conclusion from the fact that some distant events can be recalled. What is perhaps puzzling is not only the fact of long-term recall, but especially the fact that it is erratic. Temporary failure to recall, for instance, a well-remembered name is common enough. It is not in this context very easy to understand why the signal—a pattern of neural activity—should erratically wax and wane in strength. But it is highly probable that the level of neurological noise changes continuously. If long-term storage followed the basic pattern apparent for short-term memory, an acoustically coded memory trace, such as a name, would suffer the same type of distortion in noise. In attempting to recall the name three possible states would be expected according to the prevailing level of neurological noise. Complete failure to recall (executively low signal noise ratio), complete recall (adequate signal-noise ratio), imperfect recall with acoustic relationship to the original stimulus. This third state is critical and is of course everyone's experience.

There are two features of this particular type of recall relevant to the postulate of neurological noise as a factor in forgetting. The fact that first-shot recall is often acoustically similar to the original, but that one is confident that it is wrong; the fact that correct recall, if it is reached, is accompanied by complete certainty that it is right. It seems much easier to imagine a permanently established trace subject to masking by a fluctuating level of neurological noise, than to imagine a process of reconstruction from a trace merely of inadequate signal strength. Any agent which could reduce the level of neurological noise (one assumes that in the long term case it is no longer possible to raise the signal level) would facilitate recall. Russell (1959) refers to psychogenic amnesias which can be recovered by persuasion under the influence of drugs or hypnosis. It would not seem too fanciful to suppose that these and other agents affect neurological noise level. This is perhaps a too simple-minded view. But there is no doubt about the facts of remembering cited, the existence of neurological noise, the peculiar nature of recall errors, and their special relationship with certain types of perceptual error.

VI. CONCLUSION

In so far as evidence claimed to support the decay theory of immediate memory has been adduced, it has always hitherto been quantitative. An imposed delay, without rehearsal, between presentation and recall of material has led to overall more forgetting. In the present experiment, the unit of quantity has been so shifted that one can more conveniently talk of qualitative performance change. The quality, or the nature of the recall response to single-letter stimuli has been shown to change in a consistent manner before the decay point is reached when response is random with respect to the stimulus. Decay theory demands a state of partial decay as well as complete decay. This state has been demonstrated.

That the memory trace, in this kind of situation, has an acoustic or verbal basis, is at least convenient. It permits specific prediction to be made about qualitative changes in short-term forgetting when the nature of the stimulus material is manipulated. Nor is the general relationship shown here between masked listening and forgetting necessarily confined to the hearing sensory mode. In principle, non-verbal material could be examined in the same way. One would expect a visually perceived pattern which could not be named, to be recalled with the same change that would occur if the pattern were seen with visual-noise masking.

There is clearly a similarity between an information theory view of short-term forgetting most comprehensively described by Brown (1959), and the present outline. But the resemblance is often in the words used rather than in the concepts. In this paper, decay refers to a changed pattern of neural activity in a physical sense. In information theory, decay is a decrease in the signal-to-noise ratio: Of course the latter is a more general statement of the former, but carrying the implication that either signal or noise could change. In both cases though, the term noise refers to a disturbance random in relation to the signal. In the present case, it is necessary to describe this in neurological terms. Again the term redundancy has something in common with the confusability concept, but it lacks the specificity. Informationally, noise and redundancy can only be inferred from an input-output discrepancy. In the present case, noise can (in principle) be measured, confusability be controlled and the input-output discrepancy predicted. In fact it may be the vagueness of the redundancy concept when applied to memory which has led to the ill-supported prediction that span would be a function of information per item. On the other hand, it is quite obvious that the concept of neurological noise, as it has been used here, is necessarily post-Shannon.

Finally, again, the value of closely examining the nature of errors in human behaviour has been exemplified; especially when the errors can be objectively defined, counted, and treated statistically. An error indicates (the only indication) an imperfectly behaving system. Whilst measuring the amount of error in defined situations is clearly invaluable and often the best course available, the forms of malfunction may provide a short cut to an understanding of structure.

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APPEHDIX. LISTENING ERRORS, FULL ALPHABET

Stimulus latter

Response letter	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
A	.	25	9	24	18	9	35	77	19	151	200	134	45	126	478	9	8	23	22	17	28
B	2	.	171	197	107	2	142	15	13	30	11	3	11	10	4	75	94	—	2	84	33
C	2	32	.	19	24	4	19	7	3	10	4	—	4	5	—	35	30	—	2	42	4
D	4	125	71	.	166	1	104	4	12	21	6	3	11	7	—	34	47	2	—	43	11
E	8	271	195	252	.	11	208	31	100	9	16	7	59	77	9	111	66	6	6	163	65
F	10	6	4	4	4	.	3	55	2	12	30	25	13	8	6	2	–	4	336	4	4
G	4	40	22	47	34	—	.	2	9	8	5	—	3	3	1	18	39	—	3	12	33
H	27	3	15	13	22	26	3	.	1	15	28	7	9	15	34	6	16	4	43	12	2
I	1	2	5	2	14	5	4	3	.	14	6	51	52	30	23	1	5	188	21	6	5
J	10	5	6	3	1	1	12	8	—	.	158	9	4	2	7	8	7	1	2	3	8
K	46	2	7	6	—	7	—	15	7	64	.	16	9	17	21	6	12	7	7	6	1
L	69	6	2	3	4	16	6	9	35	65	42	.	32	25	73	4	6	57	38	1	2
M	106	10	14	5	13	22	22	9	31	42	73	83	.	334	24	2	7	22	21	3	6
N	234	13	21	20	35	32	31	40	47	104	127	51	512	.	59	6	6	40	38	9	12
O	116	10	5	10	18	22	26	16	31	80	80	122	15	30	.	9	8	41	26	36	15
P	7	162	350	201	172	11	167	21	12	18	39	2	31	23	4	.	231	—	5	505	16
Q	3	43	90	59	52	—	103	16	8	12	8	1	3	6	1	215	.	1	1	90	41
R	13	3	3	3	13	14	10	4	104	17	20	136	43	12	15	1	9	.	15	4	2
S	20	2	18	9	17	488	4	151	3	38	34	22	23	11	18	2	9	5	.	7	3
T	3	143	232	158	124	14	116	20	9	11	13	1	12	11	4	281	175	6	8	.	11
U	10	106	74	90	125	2	189	26	50	23	24	1	22	23	11	79	112	3	5	29	.
V	4	122	61	147	55	1	135	13	6	15	18	—	8	11	—	34	35	1	1	22	79
W	4	31	5	23	7	9	4	4	17	5	11	6	8	11	1	6	3	2	2	2	17
X	1	1	6	3	6	245	1	163	1	5	12	9	2	1	1	2	1	2	184	2	2
Y	7	5	7	1	5	7	11	3	86	98	25	62	39	11	7	1	2	32	5	7	4
Z	4	1	5	3	4	40	4	21	2	115	52	6	7	3	3	3	5	2	9	—	4
	715	1169	1398	1302	1040	989	1359	733	608	982	1042	757	977	812	804	950	933	449	802	1109	408

Total no. letters presented = 37,440.