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Contents

"The National Geographic Monthly Magazine: From Compositor's Tape to Braille"

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At the National Braille Press Inc., in Boston, we are currently midway through a project to develop the necessary software for braille production of the National Geographic magazine from the computer tapes provided by the publisher. The six steps in the project are:

1. To select a publication worthy of investment in the software. This is important because the conversion software must be specific not only to the publisher's computer system, but also to the publication itself. The National Geographic was selected because:

(a) it is desired in braille;

(b) the publisher is cooperative;

(c) clean tapes are available; and

(d) it provides ample opportunity for return on investment since it is a monthly periodical of significant length.

2. To manually convert the first issue made available (April 1979) from National Geographic computer environment and composition code to National Braille Press computer environment and composition code. This was done to gain full understanding of the job to be done by the then-unwritten conversion program.

Summary of Paper delivered June 1, 1979, at International Conference on "Computerised Braille Production - Today and Tomorrow".

3. To write the program. In preparing an input file for the Duxbury braille translator, the program carries out four basic functions:

(a) to delete unnecessary composition demands and instructions;

(b) to make a one-to-one conversion from National Geographic commands to National Braille Press commands where possible;

(c) to make more complex conversions from National Geographic commands to National Braille Press commands where algorithms within the program are necessary; and

(d) to flag those points in the text where human intervention is required.

4. and 5. To make two revisions of the program. Each of these steps is to be carried out by running several issues of the magazine through the program to determine the need for new or modified specifications to the program.

6. To write two additional programs that will assist the braillist where human intervention is required. Both these programs will be interactive and multipass. One will augment the conversion program; the other will help with braille idioms.

Conclusions

1. The conversion process is complex and expensive to develop; and the need for proofreading, verification against the ink print text, and human intervention in carrying out the conversion is not eliminated if mass-distribution-quality braille is desired.

2. Although the process is not fully automatic, clean tapes and a good conversion program can reduce the time required for translation and fabrication of plates by 75 to 90 percent.

3. Because of this time saving and because of the early availability of periodicals in machine-readable form, braille readers will receive their magazines earlier, perhaps as early as the ink print readers receive theirs.

A Microcomputer-based Braille Converter

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Summary

This paper describes a microcomputer based braille conversion system that performs French transcription at high speeds. At present, an English version of the system is under development.

Introduction

Services Converto-Braille has been producing French braille texts for seven years. Up until last year, the production system was based on a home-built relay "computer" that performed Grade two conversion. Text was input onto paper tape using Flexowriters. It was output with electromechanically-driven modified Perkins braillers, also using paper tape. It was rather obvious, given the state of the art in electronics, that some faster, more convenient system could be built. So, starting in early 1978, a more modern system began to spring up.

One of the design goals for the production system was to try to avoid duplication of effort. Thus, anything that could be bought at a reasonable price would not be redesigned. Another goal was to keep the system modular. Given future advances in electronics, the production system would be easily upgraded, without having to be rebuilt.

Experience with the relay system showed that automated braille production can be cleanly divided into three independent parts. At the heart there is a converter, that

takes in text in an "ink-print" form and converts it into three independent parts. At the heart there is a converter, that takes in text in an "ink print" form and converts it into Grade two braille. At the ends there must be something to render the text into the form that the converter can read, and an embosser to take its output and print it. Of these three parts, only the converter cannot be easily purchased.

To make text machine readable, an LSI-11 based word processing system was purchased. At first the conversion system was programmed into it. While this was not a tremendously hard task, anchoring the conversion program to the host word processing system was not consistent with keeping the system modular.

The solution was to build a small microprocessor-based converter. As an independent device, it would decouple the conversion from the input and output. The data entry problem was solved by a group of people who specialise in data entry. This allowed all of the effort to be placed into developing a converter. The result was a very small, very fast, braille conversion "box".

The Braille Conversion Box

The conversion box has physical dimensions that allow it to comfortably reside in a shoe box. It can convert up to one thousand words per minute. It produces fully abbreviated Grade two braille and allows for fairly elaborate control of the format of the final output.

The conversion box is essentially an abstraction of an abbreviations program. It resides in its own self-supporting hardware and does not contain any text editing or embossing facilities. This provides for a vastly different division of labour than exists in other automated systems. In place of one large computer responsible for

input, conversion, and output, several smaller ones are used. This is analagous to the general movement in the audio market towards "component", or modular, systems. On the market there are innumerable secretarial word processing systems, any of whicy could be used as an input station, and several braille embossers, that all produce high quality results. What has been lacking is something to tie these together. The conversion box fills this gap.

It could be argued that the conversion box is a redundant piece of hardware, given that the input system will already contain a computer into which a conversion system can be programmed. However, to do this would be more costly than using a separate piece of hardware that has already been developed. Thus the conversion box can be regarded as a program that just happens to contain a computer for it to run on. This "program" can be easily connected to any one of a number of different host systems using an industry standard interface (EIA RS232-C). By providing the conversion as an inexpensive hardware addition, any computer can be used for braille production thus bypassing the overhead associated with program development.

Using a word processor, the conversion box, and a braille embosser, a system can be constructed where the typist needs to know only a small set of rules regarding format control. The text is typed in essentially unprocessed French. When it has been edited to everybody's satisfaction, it is sent to the embosser through the conversion box and comes out in reformatted fully abbreviated Grade two braille.

The Formatter

A braille page usually has about twenty-eight lines of about thirty-five characters each. It would be impractical to have the text input in a way that conforms to that format. Also, considering that in the final

output the number of characters per line will be changed due to abbreviations, the need for reformatting is rather obvious.

The conversion box includes a formatter. It allows for the selection of any desired number of characters per line and lines per page. It has facilities for centring lines, limited tabulation and automatic page numbering. It can be asked to allow the text to pass through in its original format, or reformatted to fit any new page size. The same text can be produced to fit a variety of different page sizes without requiring any retyping.

The conversion can be made to either Grade one or Grade two braille. It can also be selectively inhibited to allow for the production of any combination of characters desired.

In truth, the system does not perform well when given mathematical or other highly technical texts. Automated processing of running text (just words, no equations or figures), though, is fairly straightforward and is completely handled by the system. The inclusion of non-alphabetic, non-numeric characters requires some special treatment. This is largely due to the deficiencies of the input system. A standard typewriter keyboard, as is commonly used, lacks many of the symbols used in a technical text.

Other Languages

The inside of the conversion box is separated into two distinct parts. There is a control program and an abbreviations dictionary. This intentional split facilitates adaptation to other languages. The control program is written in a fairly general way that includes very few French-specific features. It handles the dictionary lookup, Grade one processing, and text formatting. It is the dictionary that contains all the language specific contraction rules and exceptions.

The generation of a dictionary for a new language is not a completely straightforward task. It requires the development of a set of very mechanical rules to govern the abbreviation process. Typically the rules given to human transcribers require the understanding of how a word sounds. A computer, or any mechanical system, not being a speaker of the language, will be unable to deal with such rules. While it is possible to have the computer attempt to "sound out" a word, this is rather complicated and out of the scope of the conversion problem. Thus the rules that are published in transcribers guides can not be directly used. They must be converted to a form dealing only with vowel-consonant patterns, and letter combinations. Usually, these rules will work only most of the time, so extreme cases must be handled with an exceptions dictionary.

The development of the French rules dictionary was an iterative process. A study of the structure of French braille led to a first set of rules. These were tried out on a volume of text, and the mistakes noted. Changes to the rules were made and more text was run through the system. After about a month of "tuning" the system, the rules did a satisfactory job. By having the development paralleling production, rough edges in the system became readily apparent and quickly corrected.

Right now an English dictionary is in the works. As yet the only preliminary stage of studying the structure of the language is being done. A working English system will probably take another six months to develop. At present Grade one English braille can be produced by omitting the dictionary. A limited amount of English Grade two braille is produced by hand conversion. Even in the absence of automated conversion, computerised word processing and reformatting yields higher production than a manual system.

Other Uses

An independent, low cost conversion box can be outside of a braille production system. It can be used as a pre-processor for an embossing computer terminal to provide full Grade two braille from a computer that expects to be talking to sighted people. This will become especially useful given the accelerating tendency to store information in machine readable form. Publishers are switching over to computerised photo-typesetters. Most large industries handle correspondence through word processors. Video-text systems are springing up. High speed conversion of computer-readable text will make this growing bank of data accessible to braille readers.

With the ability to do conversion on the fly, a terminal or production system can use unprocessed text as input. This means that the text input for braille production will be useful to a wider group of people, and as such more cost effective. This will allow a sharing of machine readable text amongst a large cross section of people, independent of its eventual consumer.

The Production System

The conversion box has replaced the relay "computer" as the heart of the production system. Now, the system consists primarily of five input stations, the conversion box, an LED-120, and a zinc-plate embosser. Each input station is controlled by a small computer providing excellent text processing facilities. For a small run of a given piece of text, the LED-120 is used with the conversion box providing on the fly conversion. For a larger number of copies, zinc plates are used. A zinc-plate embosser is connected to the word processing system via a small microprocessor based controller.

Using yet another micro-based controller, a Lavender brailler was converted into a low-speed computer terminal, to allow for direct input of braille texts.

The total system contains a lot of small computers. This allows for a large amount of reliability due to redundancy. There is no central processor to fail. There is no single piece of equipment whose failure would totally stop production.

The volume of production is limited by the output devices. The LED-120 will print 300 pages per hour and the zinc-plate embosser a plate every ten minutes.

Conclusion

The conversion box is based on a Motorola 6800 microprocessor with 16K of firmware (mostly the abbreviation dictionary). Text input systems were purchased from Societe Generale de Tortue Ltee., and an embosser from Triformation Systems Inc.

The prototype that was constructed has been used on a daily basis for several months producing several thousand pages of braille text. The turnover time is fairly quick. A new text can be input at the rate of about 50 pages per day per typist. It can then be transcribed and embossed at the rate of 300 braille pages per hour. Usually a given text is embossed two or three times to allow for proofreading and corrections. With two or three typists, a standard length novel can be fully transcribed in three days.

The conversion box will sport a retail price of about two thousand dollars (Canadian). It converts text fast enough to keep any embosser that is presently on the market running at full speed. By providing an industry standard interface it will allow for the tailoring of the cost and production capacity of a conversion system. As an independent piece of hardware, it will allow braille producers to reap the benefits of advances in the computer industry, without the need for reprogramming.

This move towards modularity is an important one. With a low cost conversion box available, it will no longer be necessary to have a single large central production facility for braille. Small production systems will be affordable. Computer terminals will be able to produce Grade two braille without any need to inform the host computer that it is talking to a special device. This provides another step towards the greater accessibility of printed materials for the blind.

A Study of Braille Contractions

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Grade 2 Standard English Braille utilises 190 abbreviations and contractions. This code is used in the U.K. and in a large number of foreign countries (not only the English-speaking countries).

The American Grade 2 braille code has the same abbreviations and contractions, but the rules governing the use of the contractions differ slightly from the English code. For instance the word 'dear' uses the EA contraction in English and the AR contraction in American. Another difference is that the American code has both upper and lower case letters by the use of a capital letter sign; the English code does not normally differentiate between upper and lower case.

Many developing countries use braille in the English language; the braille books come from both the U.K. and the U.S.A. Therefore it is essential to the braille readers in these countries that the two codes do not differ to any greater extent than at present. The English code is monitored by the National Uniform Type Committee (NUTC), and the American code by the Braille Authority of North America (BANA).

The aim of this study of the braille contraction system is to identify the aspects which affect ease of learning, reading speed, writing speed, space saving and ease of production. This is the first step in determining whether any alternative system would be a significant improvement. There is no desire for any change unless it can be clearly demonstrated that there are some very considerable advantages to be gained by modifying the system.

To scientifically compare an experimental code with the existing Grade 2 code, it is necessary to specify the relative weighting given to the five factors. This can be expressed in mathematical notation as:

$$P = f(l,r,w,s,p)$$

where P is the performance index
l is the ease of learning
r is the reading speed
w is the writing speed
s is the space saving
p is the ease of production.

Assuming a simple linear function to a first approximation, and P for Grade 2 is unity, then:

$$P_e = k_l \frac{l_e}{l_2} + k_r \frac{r_e}{r_2} + k_w \frac{w_e}{w_2} + k_s \frac{s_e}{s_2} + k_p \frac{p_e}{p_2}$$

$$k_l + k_r + k_w + k_s + k_p = 1$$

where l_e is ease of learning for the experimental code
l_2 is ease of learning for Grade 2
k_l is the weighting factor for ease of learning.

However there are no established suitable measures for either l, r, w, s or p; a part of this study was to develop such measures. The determination of the weighting factors cannot be done by a purely scientific approach. Studies on ease of learning, reading speed and writing speed can be done by both macro and micro analyses. The macro approach permits experiments close to normal usage of braille but cannot provide precise data on the effects of individual contractions. Therefore it seems desirable to first study the contractions using the micro approach, and then study the overall effect of any proposed changes using macro techniques.

This article describes the technologically-related aspects of the project; the educational aspects were undertaken by the Research Centre for the Education of the Visually Handicapped.

The initial steps were a survey of the literature (see BRN No. 7, pp 25-35), and a questionnaire survey of braille users to obtain their impressions of the aspects of the contraction system which caused them most problems. The results are sumamrised in Appendix 1. The questionnaire demonstrated that the users did not want the code changed unless there were very considerable advantages by modifying the system.

A detailed analysis was done on the frequency of use of braille contractions and abbreviations for a large sample of text which had been produced in braille in the UK (a summary of results is contained in Appendix 2). For comparison, analyses were done on the Brown corpus which contains about one million words of American text (see Appendix 3).

The text was stored on computer magnetic tape so that a precise comparison of space saving for Grade 2 and any experimental code could be undertaken. In the past, studies on the braille contraction system have often concentrated exclusively on the space saving aspects. This may be attributable to the fact that space saving is the easiest factor to measure precisely. However it is important to emphasise that ease of learning, reading and writing are important factors and are not direct functions of space saving.

Another part of the project involved developing a system for accurately measuring the time taken to read individual braille cells; the timing was required to be accurate to the nearest millisecond. Based on research at Uppsala University, an on-line system was built and tested (see Appendix 4).

The measure for ease of production was proposed as the number of table entries in a specific table-controlled braille translation program needed to give a predetermined approximation to the contracted braille code. A new algorithm was developed for implementation on a microprocessor (see Appendix 5). This system has now been duplicated for use in the routine production of documents in braille.

This project has developed some of the techniques needed for a scientific study of the braille contraction system. Further studies are required involving psycho-linguists and psychologists before any recommendations can be made on possible changes to the braille contraction system.

Appendix 1

Responses to the Questionnaire on Braille Contractions

1. Name?

   N = 301

2. Address?

   All respondents lived in the United Kingdom.

3. Sex?

   167 males, 134 females.

4. Date of Birth?

   Mean age = 50.6 years, age range 20-93 years.

5. Occupation?

   131 white collar, 47 manual, 47 retired, 43 housewives, 26 unemployed, 4 students.

6. Are you able to read ordinary newspaper print (with glasses if used)?

   Yes = 69, No = 232

7. How many years ago did you begin to learn braille?

   mean = 27.9 years

8. Do you read braille by touch or by sight or by both methods?

   231 by touch, 51 by sight, 18 by both methods.

9. Can you read Grade 2 braille? Do you usually use the English or American code?

   Yes = 301, No = 0; English = 299, American = 0.

10. Which grade of braille would you prefer to read - grade 1, 2 or 3?

    2 grade 1, 260 grade 2, 32 grade 3.

11. Have you used braille some time in the last month?

    Yes = 290, No = 4.

12. About how many books in braille did you read last year?

mean = 13.4 books (68 read more than 10, 150 read 9 or less).

13. Do you use braille for writing as well as for reading?

Yes = 286, No = 5

14. Would you prefer a braille system with greater space saving than the present Grade 2 system, even if it meant using more contractions?

Yes = 165, No = 94 (of those who, from question 7, have known braille for 5 years or less - Yes = 13, No = 27; of those who have known braille for more than 5 years - Yes = 152, No = 67).

15. When designing a braille contraction system, do you think that reduction in number of braille cells is more important than increase in reading speed?

Yes = 66, No = 158.

16. Would you prefer a braille system which contracted groups of letters independent of pronunciation or meaning? For instance, a contraction would then be used whenever the groups of letters occurred even if it bridged two syllables.

Yes = 96, No = 170.

17. Specifically, would you object to the BE contraction always being used for words starting with the letters 'be'? For example, the BE contraction would be used in 'best' and 'bees'.

Yes = 140, No = 145.

18. Can you remember any contractions which gave you particular difficulty in learning?

The most frequented cited were TION, SION, CH, ST, SH, WH.

19. Which contractions do you find hardest to remember?

(a) when writing?

(b) when reading?

(a) Most frequent responses were TION, OUND, SION, EA, FUL.

(b) Most frequent responses were THOSE, WHOSE, THESE, CH, WAS, GH, WH, BY.

20. When you were learning braille was it harder to learn to feel the shapes of the signs than to remember their meanings?

Yes = 95, No = 63.

21. Is it sometimes hard for you to feel the difference between upper and lower wordsigns such as GO and WERE?

Yes = 71, No = 175.

22. Do you often have difficulty in feeling the difference between CH, K and ST?

Yes = 51, No = 189.

23. If you were designing the braille contraction system, which simple upper wordsigns would you have allocated differently? E.g. N for 'not' and K for 'knowledge'.

The most common answer was K for 'know', but other common replies were D for 'different', E for 'ever', G for 'give', K for 'kind' or 'keep', N for 'no', O for 'over', P for 'put' or 'possible'.

24. In words containing the letters 'ear', would you prefer the AR contraction to be used in preference to the EA contraction?

Yes = 90, No = 159, Indifferent = 33.

25. Which of the following contractions would you keep or delete if you were revising Grade 2 braille? Please answer using a 1 to 4 scale (1 means definitely delete, 2 means possibly delete, 3 means possibly keep, 4 means definitely keep).

	mean
REJOICING	*2.8*
WHICH	*3.9*
THYSELF	*2.7*
PART	*3.8*
BEYOND	*3.6*
WORK	*3.8*
BB	*3.4*
ONG	*3.6*
GO	*3.6*

ENOUGH	*3.4*
LORD	*3.1*
GH	*3.7*
LESS	*3.7*
KNOWLEDGE	*3.1*
OUND	*3.7*
BRAILLE	*3.7*
VERY	*3.9*

26. If you were revising the contraction system, which new contractions would you add to Grade 2 braille?

The answers were very varied but many came from braille shorthand. The general view seemed to be that if additions are made to the contraction system, then short-forms rather than wordsigns should be used. Also the use of contractions should be simplified since too many exceptions to a rule can impede learning and writing speed.

27. Which, if any, of the punctuation signs do you find difficult to read or interpret?

The most frequently cited were italics, brackets, colon.

28. Would you like the capital sign to be used wherever a capital letter occurs in the ink print?

Yes = 64, No = 215.

29. Would you like to keep the braille convention of putting the unit sign first (e.g. '20 yds' is transcribed as 'yd20')?

Yes = 146, No = 97.

30. Do you think the unit abbreviations in braille should be the same as in ink print?

Yes = 180, No = 56.

31. Would you object if non-Anglicised foreign words were transcribed into contracted braille (E.g. carte blanche)?

Yes = 44, No = 228.

32. Would you object if the contraction ST was used for the abbreviation of 'saint' as well as of 'street'?

Yes = 65, No = 211.

33. Do you prefer headings centred or inset four cells or inset two cells?

Centred = 142, four spaces = 55, two spaces = 25.

34. Do you have any other comments on the design of the braille contraction system?

The general view seems to be that there is no desire for any change unless it can be very clearly demonstrated that there are some very significant advantages to be gained by modifying the system.

Appendix 2

Analysis of Gill Corpus

A data base was assembled of 1030 short pieces in the English language. Sources included sections of novels, short stories for adults, stories for children, non-fiction as well as documents which had previously been requested for transcription by blind individuals. The corpus consists of 2,255,326 words; a word being defined as an alphabetic character string, of more than one character, which is delimited by spaces or punctuation.

Table 2.1 The frequency of contractions in order of space saved over uncontracted braille. An asterisk indicates a single cell contraction. The spaces saved by using TO, INTO and BY contractions are counted under these contractions and not as (SPACE).

	Contraction	Number of occurrences	Total number of spaces saved over uncontracted braille	Cumulative percentage of space saved
1	* THE	169553	339106	10.54
2	* AND	81763	163526	15.62
3	* ING	75481	150962	20.31
4	* ER	123778	123778	24.16
5	* TO	59173	118346	27.84
6	* IN	113930	113930	31.38
7	* ED	95699	95699	34.35
8	* EN	83887	83887	36.96
9	* OF	80243	80243	39.45
10	* ST	74849	74849	41.78
11	* AR	68436	68436	43.90
12	* FOR	33575	67150	45.99
13	* THAT	21536	64608	48.00
14	ATION	21297	63891	49.98
15	* WITH	17568	52704	51.62
16	* EA	47326	47326	53.09
17	(SPACE)	40151	40151	54.34
18	* YOU	19210	38420	55.54
19	* CH	36938	36938	56.68
20	* TH	34875	34875	57.77
21	* WAS	17249	34498	58.84
22	* OU	34390	34390	59.91
23	* SH	31403	31403	60.88
24	* CON	15565	31130	61.85
25	TION	15560	31120	62.82
26	* THIS	10361	31083	63.78
27	MENT	14999	29998	64.72
28	* FROM	9825	29475	65.63
29	* OW	29376	29376	66.55
30	* COM	14295	28590	67.43

	Contraction	Number of occurrences	Total number of spaces saved over uncontracted braille	Cumulative percentage of space saved
31	* WHICH	7105	28420	68.32
32	* HAVE	9313	27939	69.19
33	* BLE	12223	24446	69.95
34	THERE	7769	23307	70.67
35	* WH	22770	22770	71.38
36	* BY	10695	21390	72.04
37	* IT	21310	21310	72.70
38	* NOT	10409	20818	73.35
39	* HIS	10215	20430	73.99
40	* BE	19444	19444	74.59
41	* BUT	9271	18542	75.17
42	* WILL	5866	17598	75.71
43	WOULD	5861	17583	76.26
44	SHOULD	4171	16684	76.78
45	* WERE	5277	15831	77.27
46	* AS	13878	13878	77.70
47	THEIR	4521	13563	78.12
48	SION	6676	13352	78.54
49	* DIS	6626	13252	78.95
50	* PEOPLE	2641	13205	79.36
51	* GH	12875	12875	79.76
52	ANCE	6391	12782	80.16
53	ONE	12774	12774	80.55
54	PART	6338	12676	80.95
55	ABOUT	4086	12258	81.33
56	SOME	6099	12198	81.71
57	ALLY	5860	11720	82.07
58	INTO	3785	11355	82.43
59	COULD	3782	11346	82.78
60	TIME	5662	11324	83.13
61	SAID	5612	11224	83.48
62	* MORE	3710	11130	83.82
63	ENCE	5541	11082	84.17
64	WORK	5514	11028	84.51
65	YOUR	5487	10974	84.85

	Contraction	Number of occurrences	Total number of spaces saved over uncontracted braille	Cumulative percentage of space saved
66	EVER	5465	10930	85.19
67	* LIKE	3594	10782	85.53
68	UNDER	3562	10686	85.86
69	BLIND	3492	10476	86.19
70	OUND	5176	10352	86.51
71	* SHALL	2585	10340	86.83
72	THROUGH	1999	9995	87.14
73	* CAN	4882	9764	87.44
74	CHILDREN	1623	9738	87.75
75	HAD	9625	9625	88.04
76	* OUT	4680	9360	88.34
77	* VERY	3047	9141	88.62
78	LITTLE	2217	8868	88.89
79	WHERE	2918	8754	89.17
80	BEFORE	2150	8600	89.43
81	RIGHT	2848	8544	89.70
82	THESE	2808	8424	89.96
83	QUESTION	1360	8160	90.22
84	ITY	7773	7773	90.46
85	OUGHT	2565	7695	90.70
86	BETWEEN	1528	7640	90.93
87	BRAILLE	1907	7628	91.17
88	FIRST	2385	7155	91.39
89	BECAUSE	1419	7095	91.61
90	KNOW	3545	7090	91.83
91	AFTER	2306	6918	92.05
92	OUNT	3228	6456	92.25
93	* STILL	1585	6340	92.45
94	NESS	3072	6144	92.64
95	* JUST	1969	5907	92.82
96	SUCH	2812	5624	93.00
97	THOSE	1777	5331	93.16
98	AGAIN	1743	5229	93.32
99	* SO	5202	5202	93.49
100	* FF	5111	5111	93.64

		Contraction	Number of occurrences	Total number of spaces saved over uncontracted braille	Cumulative percentage of space saved
101		HIM	4988	4988	93.80
102		MUST	2483	4966	93.95
103		LETTER	1241	4964	94.11
104		GOOD	2472	4944	94.26
105		DAY	4894	4894	94.41
106	*	CC	4871	4871	94.56
107		ONG	4771	4771	94.71
108	*	EVERY	1190	4760	94.86
109	*	DO	4302	4302	94.99
110		NECESSARY	717	4302	95.13
111		AGAINST	1065	4260	95.26
112		MOTHER	1036	4144	95.39
113	*	RATHER	816	4080	95.52
114		TOGETHER	803	4015	95.64
115		ALWAYS	1331	3993	95.77
116		RECEIVE	974	3896	95.89
117		FRIEND	965	3860	96.01
118		HERE	1904	3808	96.12
119		ALSO	1900	3800	96.24
120	*	DD	3758	3758	96.36
121		PERHAPS	900	3600	96.47
122		HIMSELF	895	3580	96.58
123		MUCH	1789	3578	96.69
124		MANY	1770	3540	96.80
125		WORLD	1129	3387	96.91
126	*	QUITE	846	3384	97.01
127		CHARACTER	470	3290	97.12
128		YOUNG	1065	3195	97.22
129		FUL	3141	3141	97.31
130		GREAT	1557	3114	97.41
131		LESS	1551	3102	97.51
132	*	KNOWLEDGE	375	3000	97.60
133	*	CHILD	749	2996	97.69
134		EITHER	716	2864	97.78

	Contraction	Number of occurrences	Total number of spaces saved over uncontracted braille	Cumulative percentage of space saved
135	FATHER	713	2852	97.87
136	WORD	1370	2740	97.96
137	BEHIND	642	2568	98.04
138	NAME	1281	2562	98.12
139	IMMEDIATE	426	2556	98.19
140	ALREADY	623	2492	98.27
141	CANNOT	621	2484	98.35
142	* GG	2484	2484	98.43
143	* ENOUGH	495	2475	98.50
144	THEMSELVES	407	2442	98.58
145	ALTHOUGH	454	2270	98.65
146	ITS	2254	2254	98.72
147	AFTERNOON	344	2064	98.78
148	UPON	994	1988	98.85
149	* GO	1968	1968	98.91
150	ACCORDING	269	1883	98.97
151	ACROSS	624	1872	99.02
152	MYSELF	604	1812	99.08
153	* US	1809	1809	99.14
154	ALMOST	595	1785	99.19
155	HERSELF	439	1756	99.25
156	YOURSELF	347	1735	99.30
157	QUICK	554	1662	99.35
158	ITSELF	376	1504	99.40
159	ABOVE	748	1496	99.45
160	LORD	677	1354	99.49
161	TOMORROW	225	1350	99.53
162	PAID	641	1282	99.57
163	BELOW	419	1257	99.61
164	BESIDE	310	1240	99.65
165	* BB	1186	1186	99.68
166	SPIRIT	284	1136	99.72
167	WHOSE	378	1134	99.75
168	BEYOND	249	996	99.78
169	TODAY	277	831	99.81

170	NEITHER	179	716	99.83
171	O'CLOCK	174	696	99.85
172	BENEATH	139	695	99.88
173	TONIGHT	123	615	99.90
174	AFTERWARD	97	582	99.91
175	RECEIVING	109	545	99.93
176	ALTOGETHER	77	539	99.95
177	DECLARE	106	424	99.96
178	OURSELVES	82	410	99.97
179	DECEIVE	38	152	99.98
180	REJOICE	36	144	99.98
181	CONCEIVE	25	125	99.99
182	ONESELF	27	108	99.99
183	PERCEIVE	25	100	99.99
184	YOURSELVES	12	72	99.99
185	DECLARING	13	65	100.00
186	DECEIVING	9	45	100.00
187	REJOICING	6	30	100.00
188	PERCEIVING	3	15	100.00
189	THYSELF	3	12	100.00
190	CONCEIVING	0	0	100.00
		Total	3217789	

Table 2.2 The number of occurrences of pairs of letters.

AA	314	AN	165535	BA	13689	BN	71
AB	19916	AO	239	BB	1452	BO	18920
AC	35595	AP	19013	BC	151	BP	51
AD	36201	AQ	83	BD	101	BQ	7
AE	696	AR	92888	BE	54251	BR	14243
AF	7178	AS	71898	BF	19	BS	3337
AG	18666	AT	112716	BG	41	BT	1222
AH	1028	AU	10808	BH	99	BU	17482
AI	35566	AV	18894	BI	7671	BV	278
AJ	605	AW	6592	BJ	1398	BW	90
AK	10897	AX	1302	BK	25	BX	20
AL	81689	AY	24182	BL	24040	BY	12457
AM	23293	AZ	1023	BM	319	BZ	4

CA	41630	CN	93	DA	15572	DN	3261
CB	115	CO	66483	DB	541	DO	23764
CC	5326	CP	136	DC	367	DP	144
CD	103	CQ	260	DD	4652	DQ	83
CE	50669	CR	12359	DE	61598	DR	9501
CF	134	CS	2233	DF	908	DS	11991
CG	677	CT	29062	DG	2882	DT	232
CH	53363	CU	12046	DH	349	DU	10680
CI	22766	CV	217	DI	36941	DV	1843
CJ	7	CW	55	DJ	514	DW	784
CK	16765	CX	1	DK	90	DX	17
CL	13678	CY	2670	DL	3977	DY	4708
CM	226	CZ	80	DM	1611	DZ	14

EA	59502	EN	116169	FA	12551	FN	33
EB	2198	EO	5371	FB	35	FO	42750
EC	35674	EP	17078	FC	77	FP	6
ED	98884	EQ	8331	FD	47	FQ	1
EE	42696	ER	177348	FE	18250	FR	17724
EF	11468	ES	97487	FF	13158	FS	291
EG	9389	ET	40720	FG	44	FT	7075
EH	2734	EU	1790	FH	49	FU	8464
EI	13235	EV	19153	FI	22629	FV	1
EJ	349	EW	9775	FJ	23	FW	139
EK	2101	EX	15006	FK	4	FX	1
EL	44622	EY	15781	FL	5554	FY	649
EM	31107	EZ	516	FM	118	FZ	4

GA	13516	GN	3407	HA	87837	HN	2067
GB	254	GO	13900	HB	487	HO	45845
GC	26	GP	26	HC	140	HP	155
GD	305	GQ	0	HD	270	HQ	15
GE	33658	GR	16839	HE	261612	HR	6441
GF	76	GS	5363	HF	234	HS	1211
GG	2758	GT	1664	HG	21	HT	14110
GH	22062	GU	6034	HH	69	HU	5718
GI	12576	GV	10	HI	64760	HV	22
GJ	1	GW	104	HJ	35	HW	397
GK	14	GX	1	HK	55	HX	4
GL	5897	GY	1181	HL	1335	HY	3444
GM	330	GZ	2	HM	978	HZ	66

IA	19706	IN	205445	JA	2882	JN	103
IB	6819	IO	54872	JB	15	JO	5090
IC	54807	IP	6689	JC	45	JP	381
ID	30154	IQ	624	JD	30	JQ	0
IE	29580	IR	27571	JE	3128	JR	40
IF	17037	IS	89464	JF	3	JS	14
IG	19178	IT	92394	JG	33	JT	12
IH	356	IU	664	JH	30	JU	5442
II	1200	IV	19578	JI	189	JV	0
IJ	425	IW	38	JJ	4	JW	11
IK	5244	IX	1798	JK	66	JX	2
IL	42146	IY	14	JL	16	JY	2
IM	23948	IZ	1890	JM	70	JZ	0

KA	1192	KN	6299	LA	42157	LN	340
KB	143	KO	687	LB	918	LO	36750
KC	33	KP	186	LC	947	LP	2136
KD	75	KQ	0	LD	28745	LQ	7
KE	26971	KR	194	LE	76126	LR	729
KF	218	KS	4710	LF	5289	LS	10546
KG	182	KT	156	LG	451	LT	9269
KH	325	KU	208	LH	292	LU	9742
KI	11086	KV	69	LI	55782	LV	2286
KJ	7	KW	252	LJ	8	LW	1739
KK	62	KX	0	LK	2844	LX	13
KL	1752	KY	839	LL	60346	LY	33407
KM	174	KZ	0	LM	2154	LZ	66

MA	46721	MN	882	NA	22922	NN	7795
MB	9327	MO	25431	NB	649	NO	40422
MC	472	MP	17381	NC	30718	NP	698
MD	84	MQ	1	ND	122632	NQ	535
ME	70627	MR	6603	NE	58807	NR	645
MF	403	MS	7191	NF	4586	NS	35695
MG	53	MT	195	NG	92114	NT	78089
MH	170	MU	9760	NH	996	NU	7941
MI	29652	MV	15	NI	26805	NV	3459
MJ	5	MW	69	NJ	842	NW	586
MK	30	MX	2	NK	6719	NX	165
ML	481	MY	6597	NL	5730	NY	9698
MM	10157	MZ	2	NM	1636	NZ	243

OA	6661	ON	139716	PA	28020	PN	63
OB	7082	OO	26754	PB	175	PO	27366
OC	16010	OP	18870	PC	66	PP	14103
OD	14712	OQ	57	PD	89	PQ	7
OE	3013	OR	105249	PE	41018	PR	32529
OF	80473	OS	21821	PF	192	PS	5605
OG	6894	OT	35470	PG	33	PT	7854
OH	2583	OU	97414	PH	6428	PU	9645
OI	7961	OV	17804	PI	10856	PV	10
OJ	587	OW	34029	PJ	19	PW	136
OK	9204	OX	1274	PK	147	PX	5
OL	31327	OY	4460	PL	22177	PY	1081
OM	46527	OZ	1307	PM	1285	PZ	11

QA	27	QN	4	RA	51713	RN	13497
QB	0	QO	1	RB	1997	RO	58463
QC	1	QP	1	RC	8822	RP	2681
QD	2	QQ	5	RD	19767	RQ	117
QE	12	QR	2	RE	151685	RR	11228
QF	1	QS	9	RF	2339	RS	38935
QG	0	QT	37	RG	7503	RT	29296
QH	2	QU	11509	RH	1618	RU	9716
QI	3	QV	3	RI	54295	RV	5847
QJ	2	QW	10	RJ	52	RW	2638
QK	0	QX	0	RK	10090	RX	167
QL	5	QY	2	RL	7389	RY	23675
QM	2	QZ	1	RM	13784	RZ	82

SA	24574	SN	2292	TA	43265	TN	708
SB	828	SO	35419	TB	350	TO	93960
SC	11984	SP	15216	TC	4364	TP	402
SD	974	SQ	756	TD	468	TQ	10
SE	78381	SR	463	TE	93748	TR	33639
SF	1342	SS	33924	TF	668	TS	23316
SG	352	ST	89864	TG	262	TT	20518
SH	38471	SU	23394	TH	278813	TU	17487
SI	43276	SV	90	TI	93130	TV	92
SJ	13	SW	3428	TJ	16	TW	5904
SK	4707	SX	22	TK	56	TX	1
SL	6101	SY	3733	TL	9126	TY	16075
SM	5257	SZ	55	TM	2926	TZ	384

UA	9765	UN	35827	VA	8309	VN	4
UB	7080	UO	575	VB	32	VO	5521
UC	13903	UP	12460	VC	13	VP	6
UD	7924	UQ	22	VD	59	VQ	0
UE	10254	UR	45242	VE	69261	VR	107
UF	1730	US	37326	VF	2	VS	124
UG	11813	UT	39512	VG	5	VT	26
UH	143	UU	48	VH	14	VU	119
UI	9214	UV	204	VI	22365	VV	16
UJ	15	UW	26	VJ	2	VW	10
UK	214	UX	266	VK	2	VX	0
UL	30847	UY	452	VL	43	VY	431
UM	9856	UZ	280	VM	3	VZ	1

WA	40313	WN	7839	XA	1682	XN	2
WB	74	WO	22791	XB	17	XO	110
WC	125	WP	56	XC	1922	XP	4222
WD	554	WQ	1	XD	1	XQ	35
WE	30432	WR	3075	XE	1870	XR	20
WF	376	WS	3552	XF	228	XS	12
WG	6	WT	270	XG	3	XT	3945
WH	33244	WU	146	XH	320	XU	218
WI	36510	WV	59	XI	2062	XV	34
WJ	4	WW	16	XJ	1	XW	12
WK	193	WX	1	XK	0	XX	61
WL	1591	WY	229	XL	50	XY	37
WM	131	WZ	3	XM	31	XZ	2

YA	1928	YN	824	ZA	874	ZN	10
YB	699	YO	28031	ZB	8	ZO	366
YC	694	YP	1252	ZC	5	ZP	2
YD	437	YQ	2	ZD	6	ZQ	0
YE	10044	YR	480	ZE	2511	ZR	22
YF	120	YS	7944	ZF	2	ZS	38
YG	77	YT	1575	ZG	8	ZT	72
YH	117	YU	48	ZH	33	ZU	226
YI	2558	YV	21	ZI	982	ZV	4
YJ	20	YW	439	ZJ	2	ZW	69
YK	40	YX	2	ZK	2	ZX	0
YL	854	YY	3	ZL	170	ZY	110
YM	2497	YZ	18	ZM	14	ZZ	416

Table 2.3

The number of occurrences of the most frequent pairs of letters in the Gill corpus. Only the hundred most frequent pairs anywhere in the word have been included.

	Not preceded by a letter	Anywhere in word	Not followed by a letter
AC	8047	35595	128
AD	6336	36201	16698
AI	1766	35566	54
AL	17639	81689	30586
AN	86470	165535	27949
AR	17857	92888	10479
AS	20920	71898	38631
AT	15883	112716	46746
BE	43423	54251	18617
CA	22714	41630	512
CE	4592	50669	25020
CH	15628	53363	22907
CO	54080	66483	923
CT	38	29062	7896
DE	21235	61598	11159
DI	17190	36941	90
EA	5341	59502	2336
EC	848	35674	631
ED	3479	98884	86944
EE	63	42696	9164
EL	3275	44622	5414
EM	3511	31107	6619
EN	9967	116169	36288
ER	1126	177348	75471
ES	2650	97487	50224
ET	1091	40720	12444
FO	34765	42750	56
GE	6808	33658	12243
HA	37284	87837	268
HE	38272	261612	169862
HI	21330	64760	110
HO	15707	45845	4456
IC	632	54807	7227
ID	1300	30154	10967
IE	43	29580	3158

IL	806	42146	5204
IN	67589	205445	52170
IO	77	54872	871
IR	855	27571	8245
IS	21539	89464	44226
IT	24877	92394	27129
KE	3267	26971	10074
LA	12528	42157	865
LD	21	28745	21795
LE	13619	76126	28371
LI	18614	55782	154
LL	1714	60346	32375
LO	14829	36750	319
LY	317	33407	32113
MA	30186	46721	576
ME	19757	70627	24092
MI	12904	29652	111
NC	68	30718	263
ND	356	122632	91724
NE	13362	58807	18427
NG	45	92114	72720
NO	28624	40422	7044
NS	51	35695	16404
NT	78	78089	31635
OF	77692	80473	71954
OL	2419	31327	3216
OM	228	46527	13223
ON	28603	139716	68430
OR	15955	105249	43955
OT	4800	35470	14564
OU	8854	97414	19690
OW	2076	34029	15017
PA	19206	28020	287
PE	13220	41018	3206
PO	13496	27366	65
PR	24669	32529	75
RA	6341	51713	1722
RE	40643	151685	48977
RI	5744	54295	284

RO	11052	58463	437
RS	45	38935	23778
RT	40	29296	8941
SE	24745	78381	24902
SH	25887	38471	5239
SI	12405	43276	55
SO	22804	35419	7279
SS	116	33924	13686
ST	28252	89864	27181
TA	8992	43265	925
TE	10199	93748	15892
TH	227924	278813	26207
TI	7721	93130	319
TO	70790	93960	64756
TR	11215	33639	144
UL	178	30847	2811
UN	13553	35827	1511
UR	657	45242	11419
US	7387	37326	7890
UT	252	39512	22377
VE	6187	69261	24903
WA	32401	40313	41
WE	21268	30432	6662
WH	32460	33244	20
WI	30124	36510	14
YO	26906	28031	37

Table 2.4 The number of occurrences of the most frequent groups of three letters.

THE	189879	IVE	14797	TTE	11157
AND	82058	OUL	14753	ROM	11127
ING	76397	STA	14586	UND	11063
ION	48183	EVE	14558	FRO	11050
ENT	40419	ONE	14424	INE	10957
TIO	38621	OVE	14357	HAN	10874
HER	38412	ULD	14346	BUT	10812
FOR	35811	PER	14321	MIN	10741
HAT	28728	INT	14271	ICA	10687
TER	28015	OME	13686	OTH	10620
ATI	27815	TIN	13852	HAV	10605
ERE	27116	AVE	13698	RED	10358
YOU	26535	EST	13684	ITI	10345
THA	25686	EAR	13630	WHI	10276
ALL	24583	OUT	13576	USE	10233
HIS	23201	SHE	13561	ANT	10036
VER	22417	HOU	13483	HAD	10033
ERS	21707	GHT	13367	HEN	10029
THI	20374	DER	13283	NDE	10011
MEN	19565	AIN	13202	PRE	9983
ITH	19339	ECT	13136	NTE	9975
ATE	19278	IND	13018	EEN	9899
WAS	19101	HIN	12948	ARD	9849
WIT	18608	MAN	12818	ORT	9679
CON	18556	BLE	12752	CTI	9599
RES	18270	IST	12721	STI	9552
ARE	17802	IGH	12061	WOR	9507
OUR	17801	STR	11906	AGE	9465
COM	17589	TRA	11746	ANC	9407
NCE	16841	OUN	11627	TIC	9399
TED	16541	COU	11511	RAT	9368
ILL	16489	IDE	11456	RIN	9319
ONS	16359	PAR	11430	RAN	9235
NOT	16123	ICE	11377	WER	9203
PRO	15222	LIN	11371	ICH	9118
ESS	15107	ART	11163	END	9116
REA	15068	STE	11162	WHE	9003

ABL	8970	ITY	7817	SON	6870
ORE	8923	AST	7758	OND	6868
SHO	8819	HEY	7750	ITE	6806
CAL	8819	NOW	7748	SIO	6805
URE	8787	AME	7728	ACH	6732
CHA	8762	LAN	7687	BLI	6676
THO	8757	EME	7683	IRE	6631
IAL	8750	CES	7658	SPE	6617
UGH	8724	NIN	7650	NTR	6615
KIN	8721	EAD	7632	ARY	6610
ACT	8704	ORD	7620	STO	6591
ELL	8664	NAL	7609	POS	6554
ASS	8488	ESE	7606	TIM	6488
UST	8475	ERI	7595	WHA	6474
BER	8471	AID	7553	ERY	6468
LIT	8409	SIN	7517	SOM	6454
TUR	8367	LLY	7502	LAT	6405
APP	8342	EAT	7440	INC	6388
DIN	8325	OOK	7401	TAT	6350
OUS	8302	OUG	7383	SEN	6341
SED	8297	OWN	7338	NGE	6333
REE	8252	REN	7323	RIE	6331
ENC	8223	CIA	7290	GRE	6321
IES	8223	ITT	7279	CAT	6318
TOR	8161	WIL	7254	OLD	6274
VEN	8156	OSE	7250	CHI	6264
PLE	8073	AKE	7247	OFF	6237
LLE	8066	DIS	7238	TRE	6228
REC	8064	PLA	7205	ISH	6226
ANY	8036	SER	7155	TAN	6199
TEN	8032	ERA	7100	HAR	6197
ROU	8027	SSI	7090	ACK	6196
HIC	7972	OMM	7016	HES	6181
LEA	7968	DEN	7005	RAI	6141
CHE	7960	IME	6985	SAI	6133
CAN	7956	NED	6983	MOR	6130
LES	7943	LOW	6935	HIM	6066
EAS	7930	HEA	6930	REP	6050
INS	7832	NTS	6912	ONA	6049
NTI	7828	ONT	6879	WAR	6045

NDI	6044
ORK	6037
UNT	6025
MBE	5988
RIT	5985
BEE	5979
WOU	5964
WAY	5960
LED	5953
ABO	5941
SOC	5921
WHO	5886
ISE	5878
NES	5862
DED	5853
GRA	5852
MAT	5831
SSE	5801
POR	5799
OMP	5797
SIT	5757
SEE	5743
RIC	5736
NER	5736
BOU	5724
PRI	5712
OCI	5699
LIC	5685
TON	5673
ADE	5663
NAT	5658
EET	5631
AIL	5622
ANG	5603
OOD	5587
ASE	5585
HIL	5578
UNI	5553
PEN	5551
OLI	5528
MPL	5513
UCH	5487
ECO	5474
ERN	5461
FIC	5437
TRI	5431
HAS	5411
OST	5378
OPE	5373
TIV	5361
ACE	5358
SHA	5351
ORM	5320
HEM	5285
OLL	5277
DAY	5274
HAL	5262
SEL	5253
SID	5238
RMA	5234
CAR	5223
ENE	5217
LIS	5213
TAL	5209
LON	5191
MAR	5180
EED	5148
SES	5137
UAL	5128

Appendix 3

Analysis of Brown Corpus

The Standard Corpus of Present-Day Edited American English is described in Kucera H. and Francis W.N. "Computational Analysis of Present-Day American English", Brown University Press, Providence, Rhode Island, USA, 1967, ISBN 0 87057 105 2, 424 pp. The corpus contains 1,014,232 words of natural-language text; a word is defined as a continuous string of letters, numerals, punctuation marks, and other symbols (i.e., of graphemes), uninterrupted by space.

The contents of the corpus are:-

Subject type	Number of samples
Press: Reportage	44
Press: Editorial	27
Press: Reviews	17
Religion	17
Skills and Hobbies	36
Popular Lore	48
Belles Lettres, Biography, etc.	75
Miscellaneous	30
Learned and Scientific Writings	80
Fiction: General	29
Fiction: Mystery and Detective	24
Fiction: Science	6
Fiction: Adventure and Western	29
Fiction: Romance and Love Story	29
Humor	9

Table 3.1 The frequency of contractions in order of space saved over uncontracted braille. An asterisk indicates a single cell contraction. The spaces saved by using TO, INTO and BY contractions are counted under these contractions and not as (SPACE).

	Contraction	Number of occurrences	Total no. of spaces saved over uncontracted braille	Cumulative percentage of space saved
1	*THE	82387	164774	11.50
2	*AND	34024	68048	16.25
3	*ING	30063	60126	20.44
4	*IN	54678	54678	24.26
5	*ER	53369	53369	27.98
6	*TO	25974	51948	31.61
7	*ED	45477	45477	34.78
8	*OF	39433	39433	37.54
9	*EN	39369	39369	40.28
10	*ST	34608	34608	42.70
11	*THAT	10778	32334	44.96
12	*AR	29436	29436	47.01
13	*FOR	14431	28862	49.02
14	ATION	9180	27540	50.95
15	*WITH	8296	24888	52.68
16	*EA	21390	21390	54.18
17	(SPACE)	19424	19424	55.53
18	*WAS	9607	19214	56.87
19	*TH	16021	16021	57.99
20	TION	7805	15610	59.08
21	*THIS	5139	15417	60.16
22	*CON	7706	15412	61.23
23	*CH	14937	14937	62.27
24	*OU	14640	14640	63.29
25	*WHICH	3557	14228	64.29
26	*FROM	4357	13071	65.20
27	*HIS	6468	12936	66.10
28	*SH	12279	12279	66.96
29	MENT	6002	12004	67.80
30	*HAVE	3941	11823	68.62
31	*OW	11788	11788	69.45

32	*COM	5617	11234	70.23
33	*BY	5167	10334	70.95
34	*BLE	4912	9824	71.64
35	*WH	9759	9759	72.32
36	*WERE	3207	9621	72.99
37	THERE	3173	9519	73.65
38	*NOT	4618	9236	74.30
39	*IT	9080	9080	74.93
40	*BUT	4380	8760	75.54
41	WOULD	2849	8547	76.14
42	THEIR	2692	8076	76.70
43	*BE	7689	7689	77.24
44	*AS	7247	7247	77.74
45	*YOU	3622	7244	78.25
46	*WILL	2249	6747	78.72
47	*MORE	2214	6642	79.18
48	ENCE	3078	6156	79.61
49	*GH	6093	6093	80.04
50	ONE	6009	6009	80.46
51	SION	2972	5944	80.87
52	ALLY	2930	5860	81.28
53	EVER	2889	5778	81.69
54	SOME	2850	5700	82.08
55	THROUGH	1119	5595	82.47
56	*DIS	2754	5508	82.86
57	ABOUT	1830	5490	83.24
58	ANCE	2713	5426	83.62
59	COULD	1776	5328	83.99
60	INTO	1771	5313	84.36
61	HAD	5235	5235	84.73
62	OUND	2546	5092	85.08
63	TIME	2372	4744	85.41
64	THESE	1571	4713	85.74
65	PART	2209	4418	86.05
66	BECAUSE	882	4410	86.36
67	*PEOPLE	868	4340	86.66
68	*OUT	2168	4336	86.97
69	UNDER	1411	4233	87.26
70	FIRST	1387	4161	87.55

71	BEFORE	1018	4072	87.84
72	ITY	4066	4066	88.12
73	*LIKE	1338	4014	88.40
74	SAID	1964	3928	88.67
75	*CAN	1929	3858	88.94
76	WHERE	1259	3777	89.21
77	BETWEEN	730	3650	89.46
78	SHOULD	911	3644	89.72
79	LITTLE	850	3400	89.95
80	OUGHT	1113	3339	90.19
81	OUNT	1666	3332	90.42
82	AFTER	1105	3315	90.65
83	NESS	1595	3190	90.87
84	RIGHT	1046	3138	91.09
85	*STILL	783	3132	91.31
86	QUESTION	520	3120	91.53
87	WORK	1514	3028	91.74
88	*FF	2781	2781	91.93
89	ONG	2724	2724	92.12
90	WORLD	877	2631	92.31
91	HIM	2616	2616	92.49
92	*JUST	872	2616	92.67
93	SUCH	1301	2602	92.85
94	THOSE	849	2547	93.03
95	AGAINST	627	2508	93.21
96	KNOW	1207	2414	93.37
97	HIMSELF	603	2412	93.54
98	*VERY	793	2379	93.71
99	CHILDREN	385	2310	93.87
100	CHARACTER	323	2261	94.03
101	MANY	1126	2252	94.18
102	*CC	2195	2195	94.34
103	ALSO	1071	2142	94.49
104	GREAT	1026	2052	94.63
105	MUST	1017	2034	94.77
106	*SO	2032	2032	94.91
107	*EVERY	492	1968	95.05

108	YOUR	947	1894	95.18
109	MUCH	943	1886	95.32
110	GOOD	935	1870	95.45
111	*RATHER	372	1860	95.58
112	ITS	1858	1858	95.71
113	DAY	1846	1846	95.83
114	AGAIN	580	1740	95.96
115	*ENOUGH	339	1695	96.07
116	FRIEND	405	1620	96.19
117	THEMSELVES	270	1620	96.30
118	HERE	808	1616	96.41
119	ALTHOUGH	318	1590	96.52
120	*DD	1532	1532	96.63
121	LESS	737	1474	96.73
122	YOUNG	475	1425	96.83
123	NECESSARY	237	1422	96.93
124	ALWAYS	459	1377	97.03
125	*DO	1373	1373	97.12
126	TOGETHER	271	1355	97.22
127	FUL	1340	1340	97.31
128	ALMOST	432	1296	97.40
129	MOTHER	319	1276	97.49
130	SPIRIT	319	1276	97.58
131	PERHAPS	307	1228	97.67
132	IMMEDIATE	204	1224	97.75
133	ITSELF	305	1220	97.84
134	ACCORDING	170	1190	97.92
135	*KNOWLEDGE	145	1160	98.00
136	WORD	574	1148	98.08
137	EITHER	284	1136	98.16
138	*QUITE	282	1128	98.24
139	RECEIVE	278	1112	98.32
140	NAME	549	1098	98.39
141	LETTER	274	1096	98.47
142	*GG	1093	1093	98.55
143	ALREADY	273	1092	98.62
144	*SHALL	268	1072	98.70
145	FATHER	266	1064	98.77
146	BEHIND	258	1032	98.84

147	CANNOT	258	1032	98.92
148	UPON	510	1020	98.99
149	*CHILD	251	1004	99.06
150	*TODAY	324	972	99.12
151	ACROSS	281	843	99.18
152	WHOSE	251	753	99.24
153	AFTERNOON	122	732	99.29
154	BEYOND	177	708	99.34
155	*US	678	678	99.38
156	*GO	633	633	99.43
157	ABOVE	302	604	99.47
158	BESIDE	144	576	99.51
159	NEITHER	141	564	99.55
160	QUICK	179	537	99.59
161	HERSELF	125	500	99.62
162	*BB	454	454	99.65
163	TOMORROW	74	444	99.68
164	BELOW	147	441	99.72
165	MYSELF	129	387	99.74
166	YOURSELF	73	365	99.77
167	DECLARE	87	348	99.79
168	OURSELVES	66	330	99.82
169	PAID	165	330	99.84
170	BENEATH	57	285	99.86
171	LORD	134	268	99.88
172	CONCEIVE	46	230	99.89
173	BLIND	76	228	99.91
174	ALTOGETHER	30	210	99.92
175	TONIGHT	41	205	99.94
176	O'CLOCK	46	184	99.95
177	AFTERWARD	30	180	99.96
178	RECEIVING	34	170	99.98
179	PERCEIVE	31	124	99.98
180	DECLARING	11	55	99.99
181	YOURSELVES	8	48	99.99
182	DECEIVE	7	28	99.99
183	DECEIVING	5	25	99.99

184	ONESELF	5	20	100.00
185	REJOICING	4	20	100.00
186	CONCEIVING	2	12	100.00
187	REJOICE	3	12	100.00
188	PERCEIVING	1	5	100.00
189	BRAILLE	1	4	100.00
190	THYSELF	0	0	100.00
		Total	1432906	

Appendix 4

A Technique for Measuring Speed of Reading Braille Cells

The requirement was for a method of precisely measuring the time a finger spends reading a braille cell. One approach is to use a video recorder with the camera viewing the braille from underneath through a glass plate. The disadvantage of this method is that analysing video tapes is a very laborious process.

Another technique was developed at the University of Uppsala, and has undergone changes at Warwick.
The technique involves making the braille electrically conducting making the subject's finger part of an electrical circuit and measuring the time for which the circuit is complete.

To make the braille electrically conducting, it is necessary to deposit a thin layer of silver in columns; each column lines up with a braille cell. Suitable silver paint could not be purchased in the U.K. so paint was made from a mixture of 4-methylpentan-2-one (iso-butyl methyl ketone) and Electrodag 915 (high conductivity). A mask was manufactured by milling a sheet of brass. The paint was sprayed through the mask onto the braille embossed on paper.

The subjects were fitted with a silver-plated electrode strapped to their wrists. The subjects wore thin rubber gloves, as used by surgeons, with the index finger cut off.

The electrode was connected to a DC voltage source.

The silver strips on the braille paper were connected via a resistor network to the analogue interface of a Sigma 5 computer. The first silver strip on the left hand side of the page was connected to an interrupt which initiated the timing clock. The clock was stopped by a voice response switch activated by the subject's verbal response (speaking out the word he or she had just read). The timing was in Units of 1 millisecond.

The data is stored digitally for subsequent statistical analysis. However for the convenience of the experimenter the times are displayed on a visual display unit, next to the experimental rig, immediately after the voice response switch has been activated.

This system permits a precise study of the time the finger spends in contact with each braille cell. A possible extension would be to measure the finger pressure since it is a function of the electrical resistance.

Appendix 5

Microprocessor Braille Translator

1. Introduction

The aim of the project was to develop a compact inexpensive system for the production of contracted braille. The specification included:

(i) the operator must not be required to know braille

(ii) the system must be easy to use

(iii) the braille must be a good approximation to Grade 2 Standard English Braille

(iv) the system must require the minimum of maintenance

(v) the system must be suitable for producing from 1 to 20 braille copies embossed on paper.

2. System Description

The basic system is:

(i) input of the text on a conventional keyboard by a typist with no knowledge of braille.

(ii) proof-reading and editing of typing errors on the visual display unit.

(iii) translation of the text to a good approximation to Grade 2 braille.

(iv) output of the braille on an on-line embosser.

The basic configuration is shown in Figure 1.

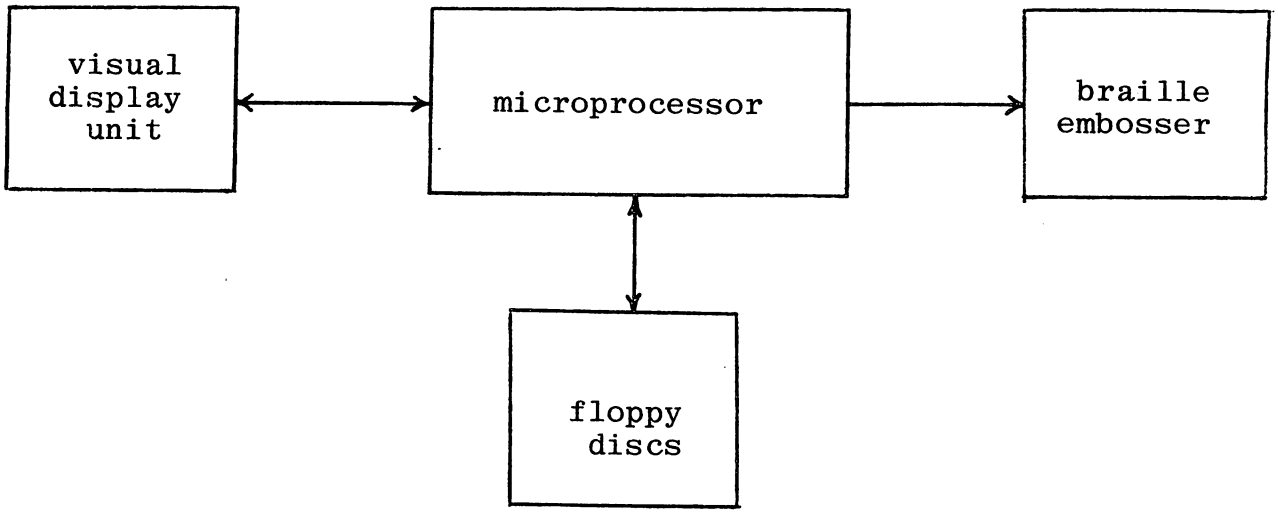

Fig. 1 Basic system configuration

3. Program Specification

This section solely refers to the program to translate the text to contracted braille. The main features of the program are:

(i) produces a good approximation to Grade 2 English braille.

(ii) able to run on a M6800 microprocessor with 32k bytes.

(iii) written in a language which is as easy as possible to implement on other microprocessors. A simple version of Fortran IV met this criterion.

(iv) machine transferability is more important than optimal use of storage.

(v) requires minimal training of the input typist.

4. Program Description

The translation program is controlled by a contraction table (see Appendix 5.1). The table is of the form:

columns	1-9	text string
column	10	previous character type
column	11	current character type
column	12	number of input characters
column	13	number of output characters
columns	14-18	output string

character types are:

L	letter
S	space or punctuation
N	number

examples

ALLY LL424Y

The text string ALLY is translated to 4Y only when ALLY is preceded by a letter.

AS$ SS32Z

The text string AS followed by space or a punctuation sign, and preceded by a space or punctuation sign is translated to Z followed by a space or punctuation sign.

$ represents one of: space . , : ; " - ! ? / ( )

The entries in the translation table are grouped by the same initial character. The program checks the first character of a string and then compares serially the text strings in the relevant part of the table. Therefore the order of the entries in the table can affect the translation.

The translated text is stored in a temporary array IOUT. Subroutine EMOUT writes the array to the output file but ensuring that a text string is not split between the end of one line and

the beginning of the next.

The program could use less memory if a subroutine were written to individually handle the bytes in an integer word (2 bytes per word). This has not been done with this version since it would make it harder to transfer the program to another microprocessor.

Appendix 5.1

Program listing (run on a Sigma 5)

Control table listing

Sample input file

Sample output file (for a LED-120)

```
!RADEDIT
:ALLOT (FILE,D3,TEMP),(RSI,10),(FSI,1000),(FOR,8)
!FORTRAN GO
C       MBT         MICROPROCESSOR BRAILLE TRANSLATOR
C                   WRITTEN BY J.M.GILL, MAY 1979
C
C       IC          CONTRACTION TABLE
C       ITAB        STORES CHARACTERS, FIRST AND LAST POSITION IN TABLE
C       IT          INPUT ARRAY
C       IOUT        OUTPUT BUFFER
C       LINES       NUMBER OF LINES OF OUTPUT ON PAGE
C       LPAGE       NUMBER OF PAGES OF OUTPUT
C       IPUNCT      PUNCTUATION SIGNS
C       LGROUP      LAST CHARACTER TYPE
C       NCT         NUMBER OF ENTRIES IN CONTRACTION TABLE
C       NTAB        NUMBER OF DIFFERENT CHARACTERS IN TABLE
C
        COMMON IOUT(50),L,LINES,LPAGE
        DIMENSION IC(18,370),IT(160),ITAB(50,3),IPUNCT(12),IPOUT(12)
        DATA IPUNCT/'  ','. ',', ',': ','; ','" ','= ','! ','? ','/ ',
       1'( ',') '/
        DATA IPOUT/'  ','4 ','1 ','3 ','2 ','8 ','- ','6 ','8 ',
       1 '/ ','7 ','7 '/
        DATA ISP,IAST,IDQ,IGO,IGC,IDOL/'  ','* ','" ','8 ','0 ','$ '/
C
C       READ IN CONTRACTION TABLE
        ITAB(1,1)=ISP
        ITAB(1,2)=1
        NTAB=1
        LGROUP=ISP
        NCT=0
   90   NCT=NCT+1
        READ(105,100) (IC(I,NCT),I=1,18)
  100   FORMAT (11A1,2I1,5A1)
        IF (IC(1,NCT).EQ.ITAB(NTAB,1)) GO TO 110
        ITAB(NTAB,3)=NCT-1
        NTAB=NTAB+1
        ITAB(NTAB,1)=IC(1,NCT)
        ITAB(NTAB,2)=NCT
  110   IF (IC(1,NCT).NE.IAST) GO TO 90
        ITAB(NTAB,3)=NCT
        NTAB=NTAB-1
        NCT=NCT-1
C
        LINES=1
        LPAGE=1
        CALL NPAGE
        L=1
        JLAST=1
        IGF=1
        DO 180 I=1,50
  180   IOUT(I)=ISP
C       READ IN TEXT
        READ (105,200) (IT(I),I=1,80)
  190   READ (105,200) (IT(I),I=81,160)
  200   FORMAT (80A1)
C
C       CHECK FOR NEW PARAGRAPH OR SKIP LINE
        IF (IT(1).NE.ISP.OR.IT(2).NE.ISP) GO TO 215
        IF (L.GT.2) CALL EMOUT
```

```
      IF (L.GT.2) CALL EMOUT
      IOUT(1)=ISP
      IOUT(2)=ISP
      L=3
      IF (IT(3).EQ.ISP) GO TO 210
C     NEW PARAGRAPH
      IF (IQF.EQ.-1) IQF=-IQF
      GO TO 215
C     SKIP LINE
  210 CALL EMOUT
  215 I=0
  220 I=I+1
C     IDENTIFY FIRST CHARACTER
      DO 230 J=1,NTAB
  230 IF (IT(I).EQ.ITAB(J,1)) GO TO 240
C     INHIBIT CONTRACTIONS
      IF (IT(I).EQ.ISP) GO TO 400
C     HANDLE QUOTATION MARKS
      IF (IT(I).NE.IDQ) GO TO 400
      IF (IQF.EQ.1) IOUT(L)=IQO
      IF (IQF.EQ.-1) IOUT(L)=IQC
      IQF=-IQF
      L=L+1
      GO TO 400
C     SEARCH ONLY RELEVANT PART OF CONTRACTION TABLE
  240 JSTART=ITAB(J,2)
      JEND=ITAB(J,3)
      DO 300 J=JSTART,JEND
      IF (IC(10,J).NE.ISP.AND.IC(10,J).NE.LGROUP) GO TO 300
      ICT=IC(12,J)
      IF (ICT.EQ.1) GO TO 255
      DO 250 K=2,ICT
      KK=I+K-1
      IFLAG=0
C
      IF (IC(K,J).NE.IDOL) GO TO 250
      DO 245 KJ=1,12
      IF (IT(KK).NE.IPUNCT(KJ)) GO TO 245
      IFLAG=1
      GO TO 255
  245 CONTINUE
C
  250 IF (IT(KK).NE.IC(K,J)) GO TO 300
  255 IF (J.EQ.2.AND.JLAST.EQ.2) GO TO 300
      LL=L-1
      IF (J.EQ.2.AND.IOUT(LL).EQ.ISP) GO TO 300
      JLAST=J
      LGROUP=IC(11,J)
      ICTT=IC(13,J)
      DO 260 M=1,ICTT
      LL=L+M-1
      MM=13+M
      IF (IFLAG.NE.1.OR.M.NE.ICTT) GO TO 260
      IOUT(LL)=IPOUT(KJ)
      IF (KJ.NE.6) GO TO 270
      IF (IQF.EQ.-1) IOUT(LL)=IQC
      IQF=-IQF
      GO TO 270
  260 IOUT(LL)=IC(MM,J)
  270 L=L+ICTT
```

```
      IFLAG=0
      I=I+ICT-1
      IF(L.GT.40) CALL EMOUT
      GO TO 400
  300 CONTINUE
  400 IF (I.LT.80) GO TO 220
      DO 500 I=1,80
  500 IT(I)=IT(I+80)
      IF (IT(1).NE.IAST) GO TO 190
      CALL EMOUT
C     CHECK QUOTATION MARKS PAIR
      IF (IQF.EQ.-1) WRITE (108,600)
  600 FORMAT (' ODD NUMBER OF QUOTATION MARKS!')
      END
C
C
C
      SUBROUTINE EMOUT
C     WRITE OUTPUT BUFFER TO OUTPUT FILE
      COMMON IOUT(50),L,LINES,LPAGE
      DIMENSION ITEMP(50)
      DATA ISP/'  '/
      DO 100 I=1,40
      II=41-I
  100 IF (IOUT(II).EQ.ISP) GO TO 200
      II=40
  200 DO 300 J=1,50
  300 ITEMP(J)=ISP
      DO 400 J=1,II
  400 ITEMP(J)=IOUT(J)
      WRITE (120,500) (ITEMP(J),J=1,40)
  500 FORMAT (40A1)
C     UNIT SPACE AT START OF LINE
      J=II+1
      IF (IOUT(J).EQ.ISP) II=II+1
      DO 600 J=1,50
      JJ=J+II
      IF (JJ.GE.49) GO TO 700
  600 IOUT(J)=IOUT(JJ)
  700 DO  800 K=J,50
  800 IOUT(K)=ISP
      L=L-II
      IF (IOUT(1).EQ.ISP.AND.L.LE.2) L=1
      LINES=LINES+1
      IF (LINES.GE.24) CALL NPAGE
      RETURN
      END
      SUBROUTINE NPAGE
C     OUTPUTS NEW PAGE AND PAGE NUMBER
      COMMON IOUT(50),L,LINES,LPAGE
      DIMENSION IALPH(10),INU(3),IPG(20)
      DATA IALPH/'J ','A ','B ','C ','D ','E ','F ','G ','H ','I '/
      DATA IHASH,ISP/'# ','  '/
C
C     WRITE NEW PAGE CHARACTER
      DO 80 I=1,20
   80 IPG(I)=168427520
      IPG(2)=185204736
      WRITE (120,100) (IPG(I),I=1,20)
  100 FORMAT (20A2)
```

11:09 MAR 26, '80 ACCT NAME: W1 FILE NAM

```
181   C
182         IF (LPAGE.LT.10) GO TO 200
183         INU(1)=IHASH
184         ITEMP=(LPAGE/10)+1
185         INU(2)=IALPH(ITEMP)
186         ITEMP=LPAGE-10*(ITEMP-1)+1
187         INU(3)=IALPH(ITEMP)
188         GO TO 500
189   C
190      200 INU(1)=ISP
191         INU(2)=IHASH
192         ITEMP=LPAGE+1
193         INU(3)=IALPH(ITEMP)
194      500 WRITE (120,600) (INU(I),I=1,3)
195      600 FORMAT (37X,3A1)
196         LINES=1
197         LPAGE=LPAGE+1
198         RETURN
199         END
200   !0LOAD GO,(UDCB,1)
201   :ASSIGN (F:120,D3,TEMP)
202   !ROV
203    -          S32--
204               S11
205   ED          L21$
206   ER00M       L55ER00M
207   ER          L215
208   ENCED       L535C$
209   ENCE       LL42;E
210   ENESS       L53E;S
211   ENOUGH     SS725
212   EN          L215
213   EAR        LL321R
214   EAR        SL32E>
215   EATION     LL63E,N
216   EA          S33EA
217   EA          L211
218   EVERY$     SS62E
219   EVER        L42"E
220   EITHER      L62E[
221   E           L11E
222   AR          L21>
223   AND THE    SS83&!
224   AND A      SS63&A
225   AND OF     SS735(
226   AND WITH   SS93&)
227   AND FOR    SS83&=
228   AND         L31&
229   ANTE        L44ANTE
230   ANTI        L44ANTI
231   ANCE       LL42.E
232   ATION      LL52,N
233   AS$        SS32Z
234   ABOUT       L52AB
235   ABOVE       L53ABV
236   AGAINST     L73AG/
237   AGAIN       L52AG
238   AFTERNOON  L93AFN
239   AFTERWARD  L93AFW
240   ALLY      LL42,Y
```

```
241  ALWAYS      L63ALW
242  ALMØST      L63ALM
243  ALREADY     L73ALR
244  ALTHØUGH    L83AL?
245  ACRØSS      L63ACR
246  ACCØRDING   L92AC
247  AFTER       L52AF
248  ALSØ        L42AL
249  AER         L32A5
250  AEN         L33AEN
251  A           L11A
252  STILL$     SS62/
253  STH         L32S?
254  STIØN       L53S•N
255  ST          L21/
256  SHØULDER    L85%/LD5
257  SHØULD      L62%D
258  SHALL      SL51%
259  SH          L21%
260  SIØN        L42•N
261  SAID        L42SD
262  SØMER       L54SØM5
263  SØME        L42"S
264  SØNE        L44SØNE
265  SØ$        SS32S
266  SEVERE      L65SEV5E
267  SPIRIT      L62¬S
268  SPHER       L54SPH5
269  SUCH        L42S*
270  SUB         L33SUB
271  SSH         L33SSH
272  S           L11S
273  THERED      L63!R$
274  THERE      SL52"!
275  THEIR       L52¬!
276  THESE       L52¬!
277  THEAST      L64?1/
278  THEART      L65TH1RT
279  THE         L31!
280  THAT$      SS52T
281  THIS$      SS52?
282  THRØUGH     L72"?
283  THØSE      SL52¬?
284  THØØD       L55THØØD
285  TH          L21?
286  TØGETHER    L83TGR
287  TØDAY      SL52TD
288  TØMØRRØW   SL82TM
289  TØNIGHT    SL72TN
290  TØ-DAY     SL62TD
291  TØ-MØRRØWSL92TM
292  TØ-NIGHT   SL82TN
293  TØ BE      SS646BE
294  TØ         SS316
295  TIØN       LL42;N
296  TIMET       L55TIMET
297  TIME        L42"T
298  TWØ         L33TWØ
299  T           L11T
300  INTØ        S5296
```

11:09 MAR 06 '80 ACCT NAME: W1 FILE NAM

```
301  INDIS      L549DIS
302  INGEN      L539GS
303  ING        L31+
304  INESS      L53I;S
305  IN.        S33IN4
306  I'.        S33IN1
307  IN         L219
308  ITY       LL32;Y
309  ITSELF     L62XF
310  IT'LL$    SS65X'LL
311  IT'S$     SS54X'S
312  IT$       SS32X
313  IMMEDIATE L93IMM
314  IR         L22IR
315  ICR0       L44ICR0
316  I          L11I
317  0F THE    SS73(!
318  0F A      SS53(A
319  0F0R       L420=
320  0F         L21(
321  0UT$      SS42!
322  0UND      LL42.D
323  0UNT      LL42.T
324  0UGHT      L52"!
325  0URSELVES L94!RVS
326  0U         L21!
327  0W         L214
328  0NG       LL32;G
329  0NER       L430N5
330  0NED       L430N$
331  0NE        L32"0
332  0'CL0CK    L730'C
333  00NE       L4400NE
334  0EN        L330EN
335  0ED        L330ED
336  0VER       L430V5
337  0          L11@
338  LIKE$     SS52L
339  LT0GETHER L92LT
340  LESS      LL42.S
341  LETTER     L62LR
342  L0RD       L42"L
343  LITTLE     L62LL
344  L          L11L
345  RIGHT      L52"R
346  RECEIVE    L73RCV
347  RECEIVING L94RCVG
348  RATHER$   SS72R
349  RARED      S65RAR$
350  REACT      L55REACT
351  REACH      L53R1*
352  REALL      L55REALL
353  REAPP      L55REAPP
354  REASS      L55REASS
355  R          L11R
356  NIGHT     LL54NI<T
357  N0NE      SL43N00
358  NAMENT     L64NA.T
359  NAME       L42"N
360  NESS      LL42;S
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E: JMCMBT PAGE 5

```
361  NEITHER    L73NEI
362  NECESSARY  L93NEC
363  NØT$       SS42N
364  NØN        L33NØN
365  NØWHERE    L75NØ:5E
366  N          L11N
367  CHILDREN   L82*N
368  CHILD'S$   SS84*'S
369  CHILD$     SS62*
370  CHARACTER  L92"*
371  CH         L21*
372  CØM        SL31-
373  CØNE       L43C@Ø
374  CØNA       L44CØNA
375  CØNY       L44CØNY
376  CØNCEIVE   SL8333CV
377  CØN        SL313
378  CØULD      L52CD
379  CØLØN      L55CØLØN
380  CANNØT     L62-C
381  CAN'T$     SS64C'T
382  CAN$       SS42C
383  CCH        L32C*
384  CC$        LS33CC
385  CC         LL213
386  C          L11C
387  DAY        L32"D
388  DØ$        SS32D
389  DISH       L43DI%
390  DISK       L44DISK
391  DIS        SL314
392  DD$        LS33DD
393  DD         LL214
394  DENCE      LL53D;E
395  DECLARING  L94DCLG
396  DECLARE    L73DCL
397  DER        L32D5
398  DED        L32D$
399  DEN        L32D5
400  DEA        L32D,
401  DE         L22DE
402  D          L11D
403  PART       L42"P
404  PAID       L42PD
405  PEØPLE'S   SL83P'S
406  PEØPLE     SS72P
407  PERHAPS    L73P5H
408  PERCEIVE   L84P5CV
409  PREDEC     L65PR$EC
410  PREDIC     L65PR$IC
411  PRE        L33PRE
412  P          L11P
413  MSELVES    L73MVS
414  MENT       LL42;T
415  MANY       L42-M
416  MØTHER     L62"M
417  MUCH       L42M*
418  MUST       L42M/
419  MYSELF     L63MYF
420  MC         SL22MC
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11:09 MAR 05,'80 ACCT NAME: W1 FILE NAME

```
421  MORE$      SS52M
422  M           L11M
423  UNDER       L52"U
424  UNLESS     SL64UN.S
425  US$        SS32U
426  UPON        L42^U
427  U           L11U
428  BUT$       SS42B
429  BEFORE      L622F
430  BEF         L322F
431  BECAUSE     L722C
432  BECA        L432CA
433  BECO        L432CO
434  BETH        L43BE?
435  BETT        L44BETT
436  BETWEEN     L722T
437  BET         L322T
438  BEHIND      L622H
439  BESIDE      L622S
440  BEYOND      L622Y
441  BELOW       L522L
442  BENEATH     L722N
443  BFH         L322H
444  BEST        L43BE/
445  BES         L322S
446  BEL         L322L
447  BEATING     L74B,T+
448  BEAT        L432AT
449  BEGG        L44BEGG
450  BEG         L322G
451  BEING       L522+
452  BEQ         L322Q
453  BEW         L322W
454  BE$        SS322
455  BLESS       L55BLESS
456  BLEED       L54BLE$
457  BLE         L31#
458  BLIND       L52BL
459  BY AND      L64BY &
460  BY         SL31C
461  BRAILLE     L73BRL
462  BBLE        L42B#
463  BB$        LS33BB
464  BB         LL212
465  B           L11B
466  FOR THE    SS83=!
467  FOR A      SS63=A
468  FOREVER    SL73="F
469  FRIEND      L62FR
470  FUL        LL32;L
471  FFOR        L42F=
472  FF$        LS33FF
473  FF         LL216
474  FATHER      L62"F
475  FEVER       L54FEV5
476  FOR         L31=
477  FROM$      SS52F
478  FIRST       L52F/
479  F           L11F
480  VERY$      SS42V
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481  VICE       SL44VICE
482  V           L11V
483  GH          L21<
484  G00D        L42GD
485  GREAT       L53GRT
486  GG$        LS33GG
487  GG         LL217
488  G0$        SS32G
489  G           L11G
490  WAS$       SS420
491  WERE$      SS527
492  WHEREVER    L84:5"E
493  WHERE       L52":
494  W0RK        L42"W
495  W0RD        L42¬W
496  W0RLD       L52-W
497  WITH THE   SS93)!
498  WITH A     SS73)A
499  WITH        L41)
500  WILL$      SS52W
501  WHICH$     SS62:
502  WH0SE       L52¬:
503  WH          L21:
504  W0ULD       L52WD
505  W           L11W
506  Y0UNG       L52"Y
507  Y0URSELF    L83YRF
508  Y0NE        L43Y@0
509  Y0UR        L42YR
510  Y0U'RE      L64Y'RE
511  Y0UHLL      L64Y'LL
512  Y0U'VE      L64Y'VE
513  Y0U'D       L53Y'D
514  Y0U$       SS42Y
515  Y           L11Y
516  HAD        SL32-H
517  HIMSELF     L73HMF
518  HERED       L53H5$
519  HERE        L42"H
520  HERSELF     L73H5F
521  HAVE$      SS52H
522  HIM         L32HM
523  HIS$       SS428
524  H           L11H
525  KN0WLEDGESS91K
526  KN0W        L42"K
527  K           L11K
528  JUST$      SS52J
529  J           L11J
530  X           L11X
531  QUICK       L52QK
532  QUESTI0N    L82"Q
533  QUITE$     SS62Q
534  Q           L11Q
535  Z           L11Z
536  1          NN11A
537  1           N12#A
538  2          NN11B
539  2           N12#B
540  3          NN11C
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541  3          N12#C
542  4         NN11D
543  4          N12#D
544  5         NN11E
545  5          N12#E
546  6         NN11F
547  6          N12#F
548  7         NN11G
549  7          N12#G
550  8         NN11H
551  8          N12#H
552  9         NN11I
553  9          N12#I
554  0         NN11J
555  0          N12#J
556  ...        S34 '''
557  .         NN111
558  .          S114
559  ,          S111
560  :          S113
561  ;          S112
562  '          S11'
563  --         S34----
564  -         SS22--
565  -          S11-
566  ?          S118
567  /          S11/
568  (          S117
569  )          S117
570  $B         S22,8
571  $C         S220'
572  * END       C0
573    WORDS
574
575  KNOWLEDGEABLE NORTHEAST CENTIMETER OPTACON DISCONNECT
576  CONCENTRATION WELCOME GRANDCHILD OUT-OF-DOORS WITHOUT STATEROOM
577  LIKELY BLEW BUBBLE ERECT MISTAKE FREEDOM IMAGERY NORTHERN
578  UNCONDITIONAL ACCOMMODATE SWEETHEART NAMED WHEREAS
579
580
581    GENERAL EXERCISES
582
583  IT WAS A TREMENDOUS EFFORT TO CLEAR THE RUBBLE AFTER THE STORM.
584  THE SNAKE PIT DEPICTS THE SHOCKING CONDITIONS IN SOME MENTAL
585  INSTITUTIONS.
586  "SHE SAID: $DI MUST GO, FOR MY KINSFOLK PRAY IN
587  THE LITTLE GRAY CHURCH ON THE SHORE TODAY.$C"
588  PORT SAID IS VERY DEPENDENT ON THE SUEZ CANAL.
589  WHEN A CHILD FIRST LEARNS HIS ABC'S, HE SOMETIMES FORGETS TO DOT
590  THE I'S AND CROSS THE T'S.
591  LINE AB IS PARALLEL TO LINE CD.
592  AL IS A POPULAR GUY.
593  IN THAT COUNTY THE TAX IS 6.5%.
594
595
596    WASHINGTON -- THE NUCLEAR REGULATORY COMMISSION HAS DECIDED IT WILL
597  NOT GRANT ANY OPERATING OR CONSTRUCTION LICENSES FOR NUCLEAR POWER
598  PLANTS UNTIL IT ADOPTS A NEW SET OF SAFETY, SITING, AND EMERGENCY
599  STANDARDS.
600    THE DECISION WILL BE DISCLOSED BY THE NRC ON MONDAY TO THE
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HOUSE COMMERCE COMMITTEE SUBCOMMITTEE ON ENERGY AND POWER.
THE MOVE WILL PROLONG WELL INTO NEXT YEAR WHAT HAS BEEN A
"DE FACTO" MORATORIUM ON NUCLEAR LICENSES SINCE THE ACCIDENT
AT THREE MILE ISLAND LAST MARCH 28. JUST HOW LONG IT WILL LAST
DEPENDS ON HOW QUICKLY THE NRC CAN DRAW UP NEW LICENSING REGULATIONS.

THE DAY WAS WARMING, AND THE 11 MEN AND WOMEN HAD BEEN SITTING
AROUND THE BROAD MAHOGANY TABLE SINCE 9 A.M., TRYING TO UNDERSTAND
TOGETHER THE PROBLEMS FACING CALIFORNIA AT THE START OF A NEW DECADE.
MOST OF WHAT WOULD BE SAID HAD BEEN SPOKEN, AND CONFERENCE
PARTICIPANT JOHN COONS TRIED TO ROLL IT ALL INTO QUESTION AND OUNCE
IT BACK:
"I'VE HEARD ANSWERS TODAY TO EVERY PROBLEM WE'VE TALKED ABOUT --
LOTS OF ANSWERS, ALL DIFFERENT.
"THE QUESTION IS -- HOW DO WE DECIDE, WHEN WE DON'T AGREE? HOW
DO WE INTELLIGENTLY APPROACH THE PROBLEM OF MAKING A DECISION, WHEN
WE ALL HAVE DIFFERENT NOTIONS OF HOW THE WORLD WORKS AND WHAT IS
GOOD FOR DIFFERENT KINDS OF KIDS?"

NATIONAL GEOGRAPHIC

WINDROWS OF FROGS LEAPED OUT OF OUR WAY, AND THE
GROUND PERIODICALLY DISSOLVED INTO FLUID MUCK. SOMETIMES WE SANK TO
OUR THIGHS, DESPERATELY CLUTCHING CYPRESS KNEES. FAT BROWN COTTONMOUTHS
SLITHERED AWAY FROM US INTO GARDENS OF LAVENDER-FLOWERING WATER
HYACINTHS. CYPRESS OIL BURST INTO IRIDESCENT CONSTELLATIONS AROUND
THE GREEN SEEDPODS SOAKING IN THE AMBER WATER, AND AS THE MORNING SUN
ROSE HIGHER, THE CHORUS OF WHISTLES AND CHIRPS BECAME LOUDER. BUT OUR
GOAL, AN EGRET ROOKERY IN SOUTHERN LOUISIANA'S ATCHAFALAYA SWAMP,
WAS WORTH EVERY MOSQUITO BITE. BEFORE US WERE HUNDREDS OF DAZZLING
WHITE EGRETS. EVERY FEW MINUTES ADULT BIRDS ALIGHTED TO REGURGITATE
CATCHES OF CRAWFISH AND MINNOWS INTO THE MOUTHS OF THEIR EXCITED
YOUNG, WHICH SEEMED TO SWALLOW THEIR PARENTS' HEADS.
WE CONTINUED DEEP INTO THE FOREST, WHERE GOLDEN RAYS OF
SUNLIGHT SHAFTED THROUGH THE LEAFY DIM LIGHT. C. C. LOCKWOOD,
PHOTOGRAPHER AND STAUNCH DEFENDER OF THE ATCHAFALAYA SWAMP, SPOTTED
A LINE OF FESTIVE RED RIBBONS TRAILING INTO THE BUSHES. "PROBABLY
BULLFROG HUNTERS," HE SAID, GRINNING. "THEY USE THE RIBBONS TO MARK
THEIR WAY INTO THE SWAMP. THE OLD-TIMERS DIDN'T NEED THEM--BUT THEY'RE
GONE. IT'S EASY TO GET LOST; SOMEHOW THE SWAMP ALWAYS LOOKS DIFFERENT."

LET US DISCUSS CULTURAL BLOCKS FIRST. WE WILL BEGIN BY
WORKING A PROBLEM THAT WILL MAKE THE MESSAGE CLEARER.

EXERCISE: ASSUME THAT A STEEL PIPE IS IMBEDDED IN THE CONCRETE
FLOOR OF A BARE ROOM AS SHOWN BELOW. THE INSIDE DIAMETER IS
1.06 LARGER THAN THE DIAMETER OF A PING-PONG BALL (1.50)
WHICH IS RESTING GENTLY AT THE BOTTOM OF THE PIPE. YOU ARE
ONE OF A GROUP OF SIX PEOPLE IN THE ROOM, ALONG WITH THE
FOLLOWING OBJECTS:

FT100 OF CLOTHESLINE
A CARPENTER'S HAMMER
A CHISEL
A BOX OF WHEATIES
A FILE
A WIRE COAT HANGER

A MONKEY WRENCH
A LIGHT BULB

LIST AS MANY WAYS AS YOU CAN THINK OF (IN FIVE MINUTES) TO GET THE BALL OUT OF THE PIPE WITHOUT DAMAGING THE BALL, TUBE, OR FLOOR.

J.P. GUILFORD, ONE OF THE PIONEERS IN THE STUDY OF CREATIVITY, SPEAKS A GREAT DEAL ABOUT FLUENCY AND FLEXIBILITY OF THOUGHT. FLUENCY REFERS TO THE NUMBER OF CONCEPTS ONE PRODUCES IN A GIVEN LENGTH OF TIME. IF YOU ARE A FLUENT THINKER, YOU HAVE A LONG LIST OF METHODS OF RETRIEVING THE BALL FROM THE PIPE. HOWEVER, QUANTITY IS ONLY PART OF THE GAME. FLEXIBILITY REFERS TO THE IDEAS GENERATED. IF YOU ARE A FLEXIBLE THINKER, YOU SHOULD COME UP WITH A WIDE VARIETY OF METHODS. IF YOU THOUGHT OF FILING THE WIRE COAT HANGER IN TWO, FLATTENING THE RESULTING ENDS, AND MAKING LARGE TWEEZERS TO RETRIEVE THE BALL, YOU CAME UP WITH A SOLUTION TO THE PROBLEM, BUT A FAIRLY COMMON ONE. IF YOU THOUGHT OF SMASHING THE HANDLE OF THE HAMMER WITH THE MONKEY WRENCH AND USING THE RESULTING SPLINTERS TO RETRIEVE THE BALL, YOU WERE DEMONSTRATING A BIT MORE FLEXIBILITY OF THOUGHT, SINCE ONE DOES NOT USUALLY THINK OF USING A TOOL AS A SOURCE OF SPLINTERS TO DO SOMETHING WITH. IF YOU MANAGED TO DO SOMETHING WITH THE WHEATIES YOU ARE AN EVEN MORE FLEXIBLE THINKER.

DID YOU THINK OF HAVING YOUR GROUP URINATE IN THE PIPE? IF YOU DID NOT THINK OF THIS, WHY NOT? THE ANSWER IS PROBABLY A CULTURAL BLOCK, IN THIS CASE A TABOO, SINCE URINATING IS SOMEWHAT OF A CLOSET ACTIVITY IN THE U.S.

TABOOS

WE HAVE USED THIS PING-PONG BALL EXERCISE WITH MANY GROUPS AND THE RESPONSE IS NOT ONLY A FUNCTION OF OUR CULTURE, BUT ALSO OF THE PARTICULAR PEOPLE IN THE GROUP AND THE PARTICULAR AMBIENCE OF THE MEETING. A MIXED GROUP NEWLY CONVENED IN ELEGANT SURROUNDINGS WILL SELDOM THINK OF URINATING IN THE PIPE. EVEN IF MEMBERS IN THE GROUP DO COME UP WITH THIS AS A SOLUTION, THEY WILL KEEP VERY QUIET ABOUT IT. A GROUP OF PEOPLE WHO WORK TOGETHER, ESPECIALLY IF ALL-MALE AND IF IT'S AT THE END OF A WORKING SESSION, WILL INSTANTLY BREAK INTO DELIGHTED CHORTLES AS THEY THINK OF THIS AND EQUALLY GROSS SOLUTIONS. THE IMPORTANCE OF THIS ANSWER IS NE THAT URINATING IN THE PIPE IS NECESSARILY THE BEST OF ALL SOLUTIONS TO THE PROBLEM (ALTHOUGH IT IS CERTAINLY A GOOD ONE), BUT RATHER THAT CULTURAL TABOOS CAN REMOVE ENTIRE FAMILIES OF SOLUTIONS FROM THE READY GRASP OF THE PROBLEM-SOLVER. TABOOS THEREFORE ARE CONCEPTUAL BLOCKS. THIS IS NOT A TIRADE AGAINST TABOOS. TABOOS USUALLY ARE DIRECTED AGAINST ACTS WHICH WOULD CAUSE DISPLEASURE TO CERTAIN MEMBERS OF A SOCIETY. THEY THEREFORE PLAY A POSITIVE CULTURAL ROLE. HOWEVER, IT IS THE ACTS THEMSELVES WHICH WOULD OFFEND. IF IMAGINED, RATHER THAN CARRIED OUT, THE ACTS ARE NOT HARMFUL. THEREFORE, WHEN WORKING ON PROBLEMS WITHIN THE PRIVACY OF ONE'S OWN MIND, ONE DOES NOT HAVE TO BE CONCERNED WITH THE VIOLATION OF TABOOS.

LET US DISCUSS A FEW MORE CULTURAL BLOCKS. THE FIRST TWO LISTED EARLIER, "FANTASY AND REFLECTION ARE A WASTE OF TIME, LAZY, EVEN CRAZY" AND "PLAYFULNESS IS FOR CHILDREN ONLY," WILL BE DISCUSSED FURTHER IN THE NEXT CHAPTER. HOWEVER, A FEW COMMENTS SHOULD BE MADE HERE. THERE IS QUITE A BIT OF EVIDENCE TO INDICATE THAT FANTASY, REFLECTION, AND MENTAL PLAYFULNESS ARE ESSENTIAL TO GOOD CONCEPTUALIZATION. THESE ARE PROPERTIES WHICH SEEM TO EXIST IN CHILDREN, AND THEN UNFORTUNATELY ARE TO SOME EXTENT SOCIALIZED OUT OF PEOPLE IN OUR CULTURE. A FOUR-YEAR-OLD WHO AMUSES HIMSELF WITH AN IMAGINARY

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11:09 MAR 06,'80          ACCT NAME: W1          FILE NAME: JMGMBT          PAGE  1

721   FRIEND, WITH WHOM HE SHARES HIS EXPERIENCES AND COMMUNICATES, IS CUTE.
722   A 30-YEAR-OLD WITH A SIMILAR IMAGINARY
723   *
724   !RADEDIT
725   :COPY (FILE,D3,TEMP),(OUT,LP)
726   : CLE BT
727   !SY
728   !FORTRANH G0
729         DIMENSION IX(90),IT(10)
730         REWIND 125
731      50 DO 200 I=1,9
732         CALL BUFFERIN (125,1,IT,10,ISTAT)
733         IF (ISTAT.EQ.3) GO TO 300
734         DO 100 J=1,10
735     100 IX((I-1)*10+J)=IT(J)
736     200 CONTINUE
737     300 CONTINUE
738         CALL BUFFEROUT (130,1,IX,90,IST)
739         IF (ISTAT.NE.3) GO TO 50
740         END FILE 130
741         END
742   !OLOAD G0,(UDCB,2)
743   :ASS (F:125,D3,TEMP)
744   :ASS (F:130,D2,D:TEMP2)
745   !ROV
746   !FIN
```

¢¢∘¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢

#A

"WS

KA# NOR?1/ C5TIMET5 OPTACON 4CONNECT
3C5TR,N WELCOME GR&*ILD |-(-DOORS)IT
/ATEROOM LIKELY #W BUB# 5ECT MI/AKE
FRE$OM IMAG5Y NOR!RN UNCONDI;NAL
A3OMMODATE WEETH1RT "ND ":AS

G55AL EX5CISES

X 0 A TREM5DIS EF"T 6CL1R ! RUB# AF !
/ORM4 ! SNAKE PIT DEPICTS ! %OCK+
3DI;NS 9 "S M5TAL 9/ITU;NS4 8%E SD2 ,8I
M/ G1 = MY K9SFOLK PRAY 9 ! LL GRAY
UR ON ! %ORE TD40'0 PORT SD IS V
DEP5D5T ON ! SUEZ CANAL4 :5 A * F/
L1RNS 8 ABC'S1 HE "S"TS =GETS 6DOT !
I'S & CROSS ! T'S4 L9E AB IS P>ALLEL
6L9E CD4 AL IS A FOPUL> GUY4 9 T C•TY !
TAX IS #F1E1

¢¢∘¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢

#B

WA%+TON ----! NLCL1R REGULATORY
=MIS•N HAS DECID$ X W N GRANT ANY
OP5AT+ OR 3/RUC;N LIC5SES = NUCL1R P45
PLANTS UNTIL X ADOPTS A NEW SET (
SAFETY1 SIT+1 & EM5G5CY /&>DS4
! DECI•N W 2 4CLOS$ O! NRC ON MON"D
6! HISE =M5CE -MITTEE SUBCOMMITTEE ON
55GY & P454
! MOVE W PROL;G WELL 96NEXT Y1R :AT
HAS BE5 A 8DE FACTOO MORATORIUM ON
NUCL1R LIC5SES S9CE ! A3ID5T AT ?REE
MILE ISL& LA/ M>* #BH1 J H4 L;G X W LA/
DEP5DS ON H4 QKLY ! NRC C DRAW UP NEW
LIC5S+ REGUL,NS4

! "D O W>M+1 &! #AA M5 & WOM5 -H BE5
SITT+ >•D ! BROAD MAHOGANY TA# S9CE #I
A4M41 TRY+ 6"U/& TGR ! PRO#MS FAC+
CALI=NIA AT ! />T (A NEW DECADE4
MO/ (:AT WD 2 SD -H BE5 SPOK51 &
3F5;E "PICIPANT JOHN COONS TRI$ 6ROLL X
ALL 96"Q & INCE X BACK3

¢¢∘¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢

#C

8I'VE H1RD ANSW5S TD 6E PRO#M WE'VE
TALK$ AB ---- LOTS (ANSW5S1 ALL
DI655T4
8! "Q IS ----H4 D WE DECIDE1 :5 WE
DON'T AGREE8 H4 D WE 9TELLIG5TLY
APPROA* ! PRO#M (MAK+ A DECI•N1 :5 WE
ALL H DI655T NO;NS (H4 ! -W "WS & :AT
IS GD = DI655T K9DS (KIDS80

N,NAL GEOGRAPHIC

W9DR4S (FROGS L1P$ | (IR WAY1 &!
GR•D P5I0DIC,1 [illegible]V$ 96FLUID MUCK4
"S"TS WE SANK 6 IR ?I<S1 DESP5ATELY
CLUT*+ CYPRESS KNEES4 FAT BR4N
C0TT0NMI?S SLI!R$ AWAY F U 96G>D5S (
LAV5D5-FL45+ WAT5 HYAC9?S4 CYPRESS 0IL
BUR/ 96IR[illegible]C5T 3/ELL,NS >•D ! GRE5
SE?P0DS S0 [illegible]+ 9 ! AMB5 WAT51 & Z !
M0RN+ SUN R0SE HI<51 ! *0RUS (:I/LES &
*IRPS 2CAME LID54 B IR G0AL1 AN EGRET
R00K5Y 9 SI!RN LIISIANA'S AT*AFALAYA
¢¢•¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢
#D
SWAMP1 O W0R? E MESQUIT0 BITE4 2F U 7
HUNDR$S (DAZZL+ :ITE EGRETS4 E FEW
M9UTES ADULT BIRDS ALI<T$ 6REGURGITATE
CAT*ES (CRAWFI% & M9N4S 96! MI?S (-!
EXCIT$ "Y1 : SEEM$ 6SWALL4 -! P>5TS'
H1DS4
WE 3T9U$ DEEP 96! =E/1 ": G0LD5 RAYS
(SUNLI<T %AFT$ "? ! L1FY DIM LI<T4 C4
C4 L0CKW00D1 PH0T0GRAPH5 & /AUN* DEF5D5
(! AT*AFALAYA SWAMP1 SP0TT$ A L9E (
FE/IVE R$ RI20NS TRAIL+ 96! BU%ES4
8PR0BABLY BULLFR0G HUNT5S10 HE SD1
GR9N+4 8!Y USE ! RI20NS 6M>K -! WAY 96!
SWAMP4 ! 0LD-"TRS DIDN'T NE$!M--B
!Y'RE G"04 X'S 1SY 6GET L0/2 "SH4 !
SWAMP ALW L00KS DI655T40

LET U 4CUSS CULTURAL BL0CKS F/4 WE W
2G9 O "W+ A PR0#M T W MAKE ! MESSAGE
CL1R54

EX5CISE3 ASSUME T A /EEL PIPE IS
¢¢•¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢
#E
IMBD 9 ! 3CRETE FL00R (A B>E R00M Z
%4N 2L4 ! 9SIDE DIAMET5 IS I4#JF L>G5
?AN ! DIAMET5 (A P+-P;G BALL 7I#A1EJ7 :
IS RE/+ G5TLY AT ! B0TT0M (! PIPE4 Y >E
"0 (A GRIP (SIX P 9 ! R00M1 AL;G)!
F0LL4+ 0BJECTS3

FT#AJJ (CL0!SL9E
A C>P5T5'S HAMM5
A *ISEL
A B0X (:1TIES
A FILE
A WIRE C0AT HANG5
A M0NKEY WR5*
A LI<T BULB

LI/ Z =M WAYS Z Y C ?9K (79 FIVE
M9UTES7 6GET ! BALL | (! PIPE)IT
DAMAG+ ! BALL1 TUBE1 0R FL00R4

J4P4 GUIL=D1 "0 (! PI"05S 9 ! /LDY (
CR1TIV;Y1 SP1KS A GRT D,L AB FLU5CY &
FLEXIBIL;Y (?"|4 FLU5CY REF5S 6! NUMB5
¢¢•¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢

#F
(3CEPTS "0 PR0DUCES 9 A GIV5 L5G? (
"T4 IF Y >E A FLOAT ?9K51 Y H A L;G LI/
(ME?0DS (RETRIEV+ ! BALL F ! PIPE4
H4"E1 QUANTITY IS 0NLY "P (! GAME4
FLEXIBIL;Y REF5S 6! ID,S G55AT$4 IF Y
>E A FLEXI# ?9K51 Y %D =E UP)A WIDE
V>IETY (ME?0DS4 IF Y ?"I (FIL+ ! WIRE
C0AT HANG5 9 TW01 FLATT5+ ! RESULT+
5DS1 & MAK+ L>GE TWEEZ5S 6RETRIEVE !
BALL1 Y CAME UP)A S0LU;N 6! PR0#M1 B A
FAIRLY =M0N "04 IF Y ?"I (SMA%+ ! H&LE
(! HAMM5)! M0NKEY WR5* & US+ ! RESULT+
SPL9T5S 6RETRIEVE ! BALL1 Y 7
DEM0N/RAT+ A BIT M FLEXIBIL;Y (?"I1
S9CE "0 D0ES N USU,Y ?9K (US+ A T00L Z
A SIRCE (SPL9T5S 6D "S?+)4 IF Y
MANAG$ 6D "S?+)! :1TIES Y >E AN EV5 M
FLEXI# ?9K54
DID Y ?9K (HAV+ YR GRIP UR9ATE 9 !
PIPE8 IF Y DID N ?9K (?1 :Y N8 ! ANSW5
IS PR0BABLY A CULTURAL BL0CK1 9 ? CASE
A TAB001 S9CE UR9AT+ IS "S:AT (A CL0SET
ACTIV;Y 9 ! U4S4
¢¢.¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢
#G

TAB00S

WE H US$? P+=P;G BALL EX5CISE) =M
GRIPS &! RESP0NSE IS N 0NLY A FUNC;N (
IR CULTURE1 B AL (! "PICUL> P 9 ! GRIP
&! "PICUL> AMBI;E (! MEET+4 A MIX$ GRIP
NEWLY 3V5$ 9 ELEGANT SURR.D+S W SELD0M
?9K (UR9AT+ 9 ! PIPE4 EV5 IF MEMB5S 9
! GRIP D =E UP) ? Z A S0LU;N1 !Y W
KEEP V QUIET AB X4 A GRIP (P :0 "W
TGR1 ESPECI,Y IF ALL=MALE & IF X'S AT !
5D (A "W+ SES.N1 W 9/ANTLY BR1K
96DELI<T$ *0RTLES Z !Y ?9K (? & EQU,Y
GR0SS S0LU;NS4 ! IMPORT.E (? ANSW5 IS
N T UR9AT+ 9 ! PIPE IS NECESS>ILY ! BE/
(ALL S0LU;NS 6 ! PR0#M 7AL? X IS
C5TA9LY A GD "071 B R T CULTURAL TAB00S
C REM0VE 5TIRE FAMILIES (S0LU;NS F !
R1DY GRASP (! PR0#M=S0LV54 TAB00S "!=E
>E 3CEPTUAL BL0CKS4 ? IS N A TIRADE AG/
TAB00S4 TAB00S USU,Y >E DIRECT$ AG/
¢¢.¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢¢
#H
ACTS : WD CAUSE 4PL1SURE 6C5TA9 MEMB5S
(A S0CIETY4 !Y "!=E PLAY A P0SITIVE
CULTURAL R0LE4 H4"E1 X IS ! ACTS !MVS :
WD (F5D4 IF IMAG9$1 R ?AN C>RI$ |1 !
ACTS >E N H>M;L4 "!=E1 :5 "W+ 0N PR0#MS
)9 ! PRIVACY ("0'S 4N M9D1 "0 D0ES N H
6BE 3C5N$)! VI0L,N (TAB00S4
LET U 4CUSS A FEW M CULTURAL BL0CKS4
! F/ TW0 LI/$ E>LI51 8FANTASY &
REFLEC;N >E A WA/E ("T1 LAZY1 EV5
CRAZY0 & 8PLAY;L;S IS = *N 0NLY10 W 2
4CUSS$ FUR!R 9 ! NEXT *APT54 H4"E1 A

FEW =;TS %D 2 MADE "H4 "! IS G A BIT (
EVID;E 69DIC^TE T FANTASY1 REFLEC;N1 &
M5TAL PLAY;L :S ~~ ESS5TIAL 6GD
9CEPTUALIZ,N4 =! >E PR0P5TIES : SEEM
6EXI/ 9 *N1 & !N UN=TUNATELY >E 6"S
EXT5T S0CIALIZ$ | (P 9 IR CULTURE4 A
FIR=Y1R=0LD :0 AMUSES HMF) AN IMAG9>Y
FR1) :0M HE %>ES 8 EXP5I;ES &
=MUNICAT~~ IS CUTE4 A #CJ=Y1R=0LD)A
SIMIL> IMAG9>Y

Appendix 5.2

ASCII to Braille Conversion for LED-120

Symbol	Braille	Symbol	Braille	Symbol	Braille
@		U		+	
A		V		'	
B		W		-	
C		X		.	
D		Y		/	
E		Z		Ø	
F		[		1	
G		|		2	
H		]		3	
I		^		4	
J		_		5	
K		SP		6	
L		!		7	
M		"		8	
N		#		9	
O		$		:	
P		%		;	
Q		&		<	
R		'		=	
S		(		>	
T		)		?	
		*			

An Adaptive Braille Transcription System - Progress Report

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1. Introduction

The major software problem in producing contracted braille by computer is similar for virtually all languages which have a contracted braille code. Each such code has a well-defined set of character strings each of which is eligible to be replaced by a braille contraction where it appears in the printed text. A set of rules defines whether a given contractable string is in fact contracted at any particular occurrence. Although some other aspects of automatic translation are not entirely straightforward, the substantial problem is the correct application of the contraction rules.

Some of the rules are easily formalised. These include those which restrict the use of a particular contraction to a certain part of a word, usually so that a single braille sign may have more than one meaning. The problematic rules are those, usually aimed at improving ease of reading, which are not easily formalised. For example: "Bridging syllables is allowed provided no confusion arises as a result, in which case the contraction should not be used". While the former type of rule can be systematically implemented by a person with no knowledge of the language in question simply by inspecting the braille rules, the latter type can be applied accurately only by a person familiar with the language. Even then there may occasionally be room for dispute among expert braillists.

Computer systems for producing contracted braille have been developed independently in various countries for most

of the major European languages: English, French, German, Danish, Dutch, Portuguese, Spanish. With the exception of Dotsys III, a computer program developed in the United States for production of American-English braille, each system has been developed and used only for the transcription of one particular language into braille.

There has thus been a considerable duplication of effort because of the similarities between braille codes, but most of the existing translation algorithms would need significant modification if they were to have a more general application. Several, for example, divide the input text into words before determining contractions this would be inadequate for English braille, where certain contractions (TO, INTO, BY) require consideration of a wider context.

Of the existing algorithms, Dotsys III, a table-driven finite-state syntax-directed translator, appears to be the most adaptable. The Duxbury Braille Translator, a proprietary system based on the Dotsys algorithm, has a set of tables for producing contracted Spanish braille in addition to its tables for American-English braille. However, preparation and modification of the tables can be done only by someone with a good knowledge of the way in which the translation algorithm works. It has been found in practice that anomalies in the translation can emerge over a long period of usage of the system, and minor changes to the tables must be made to correct these. If not done sufficiently skillfully, these changes may themselves introduce new miscontractions.

2. Adaptive Braille Transcription System

The Adaptive Braille Transcription System (ABT) is envisaged as a self-contained computer system whose software will embody the principles of braille codes in a

generalised form. The contractions and rules for their use in a given language are to be specified by a braillist in a form which will require neither general computer expertise nor a knowledge of the internal working of this particular system. In use, the system would be adapted by the braillist (hence the term "adaptive system") to eliminate inaccuracies in the translation, so that over a period of time the system would converge on a fully correct transcription within its overall limitations. The system is intended to be a stand-alone braille production system comprising a microcomputer with disk unit, a visual display unit for control and text input, and a braille embossing terminal. The major application is foreseen in developing countries with a large and increasingly literate blind population but little expertise in computer programming available. It could also be used in helping to test and evaluate proposed braille contraction systems for languages which do not currently have one, or proposed braille code revisions for those which do.

The software, written in FORTRAN IV, is currently being developed on a Prime 550 computer. It involves four major components: a translator, a formatter, a program for the interactive creation and modification of the translation tables, and a program for the analysis of text already translated so that the repercussions of changes to the translation tables may be assessed.

The translator and formatter taken together perform the same function as existing braille translation systems. The implementation of the main translation process as two separate passes gives a useful reduction in main memory requirement, since the two parts each account for roughly half the total.

Several aspects of the translator, and the major part of the formatter, have been based on Dotsys III, the most widely-used program for production of English braille.

However, for an adaptive system the translation tables must be organised in such a way that they can be amended in use easily and without undesired side-effects. Careful consideration and experience of the use of Dotsys III shows that its tables do not satisfy this criterion. They contain an undifferentiated list of text strings, including the contractions themselves and various other text strings whose recognition forces or prevents the making of the various contractions. These text strings do not necessarily contain the relevant contraction as a substring, and for some of them it is not obvious, without a careful analysis of the tables as a whole, why certain entries are included, or what would be the exact effect or removing or changing them. The method is designed for efficiency of translation but is not suitable for adaptation of the tables by a non-specialist for a different language or proposed braille code revision.

The arrangement of the ABT tables is therefore more similar to that adopted in translation systems for German braille. The principal table entries represent the contractions themselves, single characters, format control strings, and words requiring special treatment, such as units of measure. The entries for rules governing the use or non-use of a particular contraction are attached specifically to the entry for that contraction. Their effect is thereby localised and does not generally affect other contractions. Care is needed in the case of overlapping potential contractions. For example, the abolition of the "OU" contraction in Standard English Braille (SEB) would result in the unexpected and erroneous contraction of "UPON" in "COUPON" unless this has been specifically countered. Scanning of the principal entries is implemented as a tree search as in Dotsys III.

The rules for identifying whether or not a contraction is applied are implemented as a test on left and right contexts of the candidate text string when it is identified.

This contrasts with the finite-state method of Dotsys III, in which the left context is largely encapsulated in a set of state variables which are constantly updated as translation proceeds, the right context is taken as the class of the immediately following character, and any context restrictions which do not fit either of these two tests are built into the text strings of the table entries. The use of finite-state parsing is inherently more powerful than a purely bounded-context analysis, but the extra power is not strictly necessary for braille translation. One consequence of the change to a simple context check is a difference in the implementation of the rules regarding prefixes in English braille.

Each ABT context rule includes an action code which, if the specified context is recognised, determines whether the contraction is accepted or rejected, or whether the entry is a special one such as a format control or unit of measure. A change of braille grade or language within a text is effected by introducing an appropriate set of tables from backing store into main memory in place of the current tables.

3. Interactive Table Definition

The most significant difference between the ABT system and previous braille translation systems is the means of creating and maintaining the translation tables. This is done by a program which holds a dialogue with the user sitting at a visual display unit. It is important that the dialogue should take as natural a form as possible because the user is presumed to be totally unfamiliar with computers, and possibly apprehensive of their use.

The interactive program may be regarded as an interpreter for a "program" whose "statements" each consist of a message to be displayed, a list of acceptable user responses, and an action and branch to be taken for each of

these possible replies. Questions may expect YES/NO answers, or offer a multiple choice of answers for selection by typing a single digit, or expect a free-format reply, for example, the text of a contraction. In each case a carriage-return typed alone by the user is accepted as a request for help and further information is given, if available, on how to answer the question. At each stage, the program takes the initiative in deciding what further information it requires, and asking for it.

The initial definition of a set of translation tables will require the user to enter the characters of the language, the braille equivalent for each, the text strings which may form contractions, the principal context restrictions (for example, "only at the start of a word") and braille equivalent for each contraction, and special features, including formatting controls and, if appropriate, units of measure.

Subsequent modification of the tables will be made following the translation of some text using the tables, by requesting the user to enter wrongly translated text together with the correct braille equivalent. The dictionary of known translations, maintained by the analysis program, will be searched to determine a context rule which will satisfy the user's specification without corrupting the translation of words already correctly translated. If a mistranslated word has been translated previously without complaint from the user, this will be drawn to the user's attention. It may indicate that a context extending beyond the single word must be tested in this case.

Analysis of the frequency of access by the translator of the various rules in the table may cause the program to change the order of these rules to improve the speed of translation, provided that the accuracy is not affected. This process will be transparent to the user.

4. Current State of Development

The translation and formatting programs have been in use for the production of Standard English Braille for several months. The accuracy of braille produced is slightly better than that of the version of Dotsys III which they superseded. The SEB translation table was created directly without the use of the table definition program, using the Dotsys III tables as a starting point, enhanced by additional entries to give a correct translation of all problem words listed in the Royal National Institute for the Blind's manual for SEB. It has not yet been determined how long it would take in practice to converge on this quality of translation starting from scratch. The interactive program is still under development but should be tested in the near future.

Manuals for a number of braille codes have been obtained from various countries to assess the diversity of problems involved. These include the contracted codes of Portuguese, Danish, Arabic, Spanish, and several South African languages. Other manuals are on order. Some countries have unfortunately not yet published their braille systems.

Samples of printed text with corresponding manually produced braille have been requested from a number of countries and have so far been received from Brazil (Portuguese) and South Africa (Tswana, North and South Sotho). Preliminary tests on the Tswana language suggest that it can be translated accurately by the ABT system.

The current speed of translation by ABT is somewhat slower than that of the version of Dotsys III which it replaced. This may be regarded as a trade-off against the increased adaptability. The speed of translation is not expected to be critical in a stand-alone system since the proportion of time spent on translation will be small compared with that needed for text preparation and editing

or braille embossing. The programs have not yet been tested on a microcomputer but no major difficulties in transfer are anticipated.

5. Acknowledgements

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Recent Publications and Reports

Hampshire B *"Establishing Braille Production Facilities in Developing Countries"*. Swedish Federation of the Visually Handicapped, S-122 88 Enskede, Sweden, 1980, 165 pp.
A most informative factual handbook which will be of interest to those thinking of setting up a small braille production system in both the developed and developing countries. Of particular interest are the financial estimates for the various production systems in current use.

Harley R.K., Henderson F.M. & Truan M.B. *"The Teaching of Braille Reading"*. C.C. Thomas, Illinois, USA, 1979, ISBN 0-398-03836-8.
A useful book for both those interested in studying braille reading as well as for those concerned with studies of the contracted braille code.

Truquet M. *"Transcription en Braille Integral ou Abrege"*. Ph.D. thesis contains a full account of Monique Truquet's work, over the last decade, on designing an algorithm for producing contracted French braille.

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