Alignment of Braille and Print English for Learning and Instruction

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Abstract

We examined the relationship between English and the braille code as it may affect beginning readers. Specifically, we used the Educator’s Word Frequency Guide (Zeno, Ivens, Millard, & Duvvuri, 1995) to determine how frequently braille characters occur in English texts. Results suggest that braille contractions are a generally strong representation of printed English. In terms of the instructional sequence, early braille lessons tend to prioritize characters with easily recognizable dot configurations, but many later lessons appear to group contractions and shortform words that are similar without consideration of how frequently they occur in print (e.g., teaching thyself with yourself). We concluded that, despite its nineteenth century French genesis, the braille system represents current English orthography efficiently, but that braille instructional practices could be refined to support earlier acquisition of important features of English.

Alignment of Braille and Print English for Learning and Instruction

Though braille was not the first writing code for the blind, it has been the prevailing code since the late 1800’s. Braille’s code for the blind made it to the United States in 1866, but was not used consistently until adopted as a uniform code in 1918 (Irwin, 1955). Since that time, the English braille code has grown and been revised to reflect changes and additions to English print (e.g., prevalence of the @ sign in web addresses). The most recent change to the code in the US being the adoption and implementation of Unified English Braille (UEB).

**Connection to the Organization of English**

Because braille has a uniform size, braille texts tend to be larger than printed texts. This led to the use of contractions to reduce the length of texts. Broadly speaking, there are two classes of contractions: those that represent letter combinations, called groupsigns; and those that represent words, called wordsigns. The groupsigns include consonant digraphs (e.g., *ch*), vowel digraphs/diphthongs (e.g., *ea, ou*), syllable bodies/orthographic rimes (e.g., *en, ong, ount*), orthographic onsets (e.g., *st*), and morphemes (e.g., *tion, sion*).

Though braille has evolved since its creation, there are many aspects of the code that remain from 1829. For instance, Braille’s selection of which dot configurations would represent the letters of the alphabet has been maintained. The reason for this lies with his systematic choice to use configurations that would limit confusion as much as possible (NLS, 2000). His decisions were based on hands-on experience with the code, but Nolan and Kederis’ (1969) research, more than a century later, supports Braille’s original choices. Considerations such as the number of dots in a character and the position of the dots affect the recognition threshold for reading words in braille. Nolan and Kederis (1969) found that individual braille characters took significantly more time to recognize when they had more dots. For instance, when a character had 2 dots, it took a mean time of .033s to recognize and when a character had 5 dots it took a mean time of .128s to recognize. The position of the dots in a cell also had a significant effect on reaction time, with dots 1 and 4 the fastest to recognize, dots 2 and 5 coming next, and dots 3 and 6 taking the longest and causing the most errors in recognition. For example, the letters of the alphabet all include at least one dot in the top of the braille cell, which we know leads to faster recognition.

**Current Braille Instructional Practice**

When teaching literacy in kindergarten, there are many ready-made programs, curricula, and other materials available. Some are arguably better than others, some are rooted in evidence, some are designed for a specific purpose, some target one population or another – but most are highly motivating, colorful, and easy to obtain. For students with visual impairments, specifically students learning braille, this is not the case. Though several programs exist, *Building on Patterns* (2006)is often the go-to curriculum for younger students learning braille, because it is a reading program created specifically to teach braille contractions in a systematic way.

Like other formal reading programs, *Building on Patterns* assigns a specific letter order to its curriculum. However, the order of instruction in *Building on Patterns* does not align with reading programs most commonly used in early elementary classrooms. Though braille is unique in the fact that letters can also represent words, it stands to reason that aligning braille instruction more closely with the order of instruction used in print English reading curricula would increase success as well as increase phonemic awareness, concepts about print, and general ability to participate in the general education setting. This is of concern because the percentage of students with visual impairments spending more than 60-80% of their time in the regular classroom has more than tripled in the past 10 years (16.6% in 2002 to 64.7% in 2012) and continues to increase (USDOE, 2004, 2014).

**Research Questions**

Braille is interesting in that it was designed to map onto an existing orthographic system. However, UEB has requirements that printed orthography does not, notably that contracted forms of some words are used to reduce the volume of text. It is interesting, then, to consider whether UEB reflects the properties of the English orthography, particularly given that some decisions about the code were made more than two centuries ago. Our research questions concern whether braille contractions provide a useful and efficient representation of the printed language.

1. How frequently do words represented with contractions occur in print and does this reflect the frequency of words in printed English? Are there more frequent words that could be represented in braille to improve efficiency?
2. Does the recommended order of instruction for braille contractions align well with the frequency of occurrence of letters, letter combinations, and words in English?

**Method**

**Database**

The database used was the *Educator’s Word Frequency Guide* (EWFG, Zeno, Ivens, Millard, & Duvvuri, 1995). The EWFG is a database of 143,871 English word forms. For our purposes, an important feature of the EWFG is that it provides frequency ratings for English texts from Grades 1 through 12 and college in addition to overall frequency across texts for adults. The grade-specific frequencies allow us to understand the utility of a word at each grade level, particularly important for determining whether the order of introduction of braille in the *Building on Patterns* curriculum reflects the frequency of those features in printed English.

**Analyses**

To analyze research question 1, a computer program was constructed to calculate the number and frequency of words in the EWFG. The second part of this question regarded the current efficiency of wordsigns, including initial-letter contractions. Efficiency was defined as (1) a word’s length, with longer words being more efficient; and (2) a word’s standardized frequency index (SFI) from the EWFG, with more frequent words being more efficient. The mean of these two standardized (z-scored) values for a given word represented its efficiency index. Efficient wordsigns, therefore, were those that were longer and more frequent.

To answer research question 2, we calculated the rank frequency of letters, groupsigns, and wordsigns, including initial-letter contractions within their respective categories, with the most frequently occurring ranked “1”. For example, the letter *e* is the most frequent of English letters in the EWFG, so it received a rank of “1”. *Q* is the least frequent letter and was assigned a rank of 26. We also calculated a rank for specific contractions, meaning that we ranked the 60 letters and groupsigns by their frequency of occurrence, regardless of their length. For this calculation, *e* was still the most frequent. However, some bigrams like *er* were more frequent than letters like *z* (ranks of 18 and 35, respectively). The calculation for words was based on the frequency per million words within the EWFG, with the most frequent word (*the*) being assigned a rank of “1”. In addition, we calculated a rank for each of the words taught within the set of 148 wordsigns, initial-letter contractions, and shortform words.

**Results**

**Research Question 1**

For the first part of research question 1, we examined how often the words represented by braille contractions occur in print. Table 1 shows the 50 most frequent words in the EWFG and

Table 1

*The Fifty Highest Frequency English Words*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Rank | Frequency† | Word |  | Rank | Frequency† | Word |
| 1 | 56699 | the |  | 26 | 4408 | are‡ |
| 2 | 24203 | to |  | 27 | 4251 | have |
| 3 | 23075 | and |  | 28 | 4251 | as |
| 4 | 22531 | a |  | 29 | 3970 | be |
| 5 | 16310 | of |  | 30 | 3838 | all |
| 6 | 13684 | in |  | 31 | 3829 | what‡ |
| 7 | 12573 | he |  | 32 | 3772 | up |
| 8 | 11894 | you |  | 33 | 3652 | this |
| 9 | 11539 | it |  | 34 | 3621 | one |
| 10 | 11436 | I |  | 35 | 3489 | there |
| 11 | 10740 | was |  | 36 | 3416 | out |
| 12 | 8154 | that |  | 37 | 3387 | we |
| 13 | 7882 | said |  | 38 | 3359 | from |
| 14 | 7868 | is |  | 39 | 3327 | when‡ |
| 15 | 7065 | on |  | 40 | 3257 | were |
| 16 | 6558 | she‡ |  | 41 | 3216 | do |
| 17 | 6421 | they‡ |  | 42 | 3051 | can |
| 18 | 6338 | for |  | 43 | 2984 | then‡ |
| 19 | 6191 | his |  | 44 | 2966 | my |
| 20 | 5354 | at |  | 45 | 2802 | him |
| 21 | 5058 | had |  | 46 | 2772 | so |
| 22 | 4920 | with |  | 47 | 2723 | like |
| 23 | 4914 | but |  | 48 | 2706 | about |
| 24 | 4585 | her‡ |  | 49 | 2602 | me |
| 25 | 4424 | not |  | 50 | 2588 | your |
| † Frequency per million words  ‡ Word contains braille contraction | | | | | | |

their representation in braille. There are 33 words in the top 50 with an exact braille representation. There are another seven words with proxy representation, meaning the word contains a braille contraction (e.g., *she*). That leaves only ten words in the top 50 written without any contractions. On the other hand, Table 2 shows the standardized frequency index (SFI) of all the braille wordsigns, initial-letter contractions, and shortform words in addition to their frequency per million in texts in Grade 1, 4, 7, and 10. This table shows that there are three words represented in braille that never showed up at any grade level in texts in the EWFG. This also shows 24 words that show up fewer than 100 times per million words at any grade level.

Table 2

*Braille Word List with Standardized Frequency Index and Selected Grade Level Frequencies*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Word | SFI | Frequency per Million | | | |
| Grade 1 | Grade 4 | Grade 7 | Grade 10 |
| the | 88.3 | 50950 | 59629 | 69603 | 72050 |
| of | 84.6 | 8779 | 19173 | 27744 | 32106 |
| and | 84.4 | 17513 | 25476 | 28675 | 28473 |
| a | 83.8 | 21811 | 23295 | 24683 | 24828 |
| in | 82.8 | 10423 | 15075 | 18986 | 20447 |
| that | 80.1 | 6087 | 9162 | 10431 | 10779 |
| it | 79.7 | 12605 | 11511 | 9795 | 8564 |
| was | 79.4 | 9923 | 11399 | 9530 | 8197 |
| for | 79 | 5851 | 6559 | 7632 | 8169 |
| you | 78.8 | 15472 | 11001 | 7508 | 6202 |
| as | 78.1 | 2243 | 5049 | 6487 | 7029 |
| with | 77.7 | 4181 | 5353 | 6015 | 6157 |
| be | 77.2 | 3366 | 4229 | 4753 | 5500 |
| his | 76.9 | 5402 | 6606 | 5509 | 4553 |
| i | 76.5 | 19316 | 9129 | 4300 | 2651 |
| had | 76.5 | 3649 | 5846 | 5401 | 4740 |
| from | 76.5 | 2044 | 3909 | 4820 | 4998 |
| not | 76.4 | 5662 | 4189 | 4319 | 4290 |
| have | 76.3 | 4736 | 4229 | 4140 | 4193 |
| this | 76.3 | 3899 | 3712 | 4205 | 4435 |
| but | 76.1 | 5172 | 4924 | 4244 | 3727 |
| were | 75.7 | 2300 | 3623 | 4122 | 4024 |
| one | 75.5 | 3476 | 3724 | 3788 | 3638 |
| their | 74.8 | 660 | 2213 | 3118 | 3376 |
| there | 74.8 | 3255 | 3663 | 3330 | 2856 |
| can | 74.3 | 5068 | 2497 | 2352 | 2455 |
| about | 74.1 | 1862 | 3028 | 2906 | 2472 |
| said | 73.8 | 17700 | 4514 | 1586 | 849 |
| some | 73.7 | 2171 | 2239 | 2344 | 2355 |
| would | 73.7 | 1957 | 2808 | 2561 | 2270 |
| out | 73.7 | 3825 | 3311 | 2588 | 2022 |
| people | 73.6 | 1326 | 2412 | 2650 | 2461 |
| so | 73.6 | 2778 | 2854 | 2450 | 2130 |
| more | 73.3 | 902 | 1651 | 2165 | 2361 |
| Word | SFI | Frequency per Million | | | |
| Grade 1 | Grade 4 | Grade 7 | Grade 10 |
| which | 73.3 | 209 | 905 | 2006 | 2722 |
| will | 73.3 | 4845 | 1755 | 1798 | 1989 |
| your | 73.3 | 2554 | 2657 | 2292 | 2164 |
| do | 73.2 | 4560 | 2808 | 1960 | 1577 |
| many | 72.9 | 788 | 1526 | 2074 | 2146 |
| these | 72.8 | 525 | 1238 | 1943 | 2184 |
| like | 72.6 | 3487 | 2545 | 1949 | 1514 |
| time | 72.6 | 1847 | 1987 | 1939 | 1817 |
| could | 72.5 | 2078 | 2386 | 1915 | 1592 |
| him | 72.3 | 2780 | 2854 | 1906 | 1440 |
| its | 71.4 | 294 | 800 | 1363 | 1635 |
| first | 71.4 | 745 | 1250 | 1492 | 1498 |
| very | 71.1 | 1539 | 1579 | 1424 | 1235 |
| also | 71 | 160 | 803 | 1272 | 1455 |
| just | 70.6 | 2152 | 1761 | 1112 | 851 |
| after | 70.5 | 986 | 1156 | 1198 | 1175 |
| through | 70.4 | 343 | 1009 | 1207 | 1171 |
| know | 70.3 | 2010 | 1636 | 1028 | 768 |
| where | 70.3 | 1477 | 1287 | 1147 | 981 |
| little | 70.3 | 3112 | 1467 | 1039 | 865 |
| because | 70.3 | 463 | 1001 | 1054 | 1108 |
| such | 70.2 | 144 | 466 | 849 | 1123 |
| much | 70.1 | 698 | 998 | 1158 | 1081 |
| must | 70 | 818 | 851 | 915 | 989 |
| before | 70 | 535 | 1089 | 1152 | 1097 |
| good | 70 | 1989 | 1229 | 983 | 867 |
| day | 69.8 | 1977 | 1347 | 1028 | 804 |
| work | 69.7 | 874 | 772 | 894 | 950 |
| go | 69.7 | 3313 | 1549 | 847 | 553 |
| great | 69 | 373 | 550 | 891 | 933 |
| should | 68.9 | 410 | 547 | 681 | 827 |
| right | 68.9 | 1499 | 1075 | 706 | 534 |
| still | 68.6 | 699 | 825 | 800 | 737 |
| us | 68.4 | 997 | 871 | 700 | 586 |
| world | 68.4 | 150 | 476 | 738 | 777 |
| part | 68.4 | 219 | 540 | 793 | 808 |
| those | 68.2 | 262 | 439 | 560 | 673 |
| every | 68.2 | 451 | 688 | 715 | 681 |
| here | 68.2 | 2267 | 988 | 607 | 426 |
| between | 68 | 79 | 352 | 555 | 700 |
| again | 67.9 | 1035 | 922 | 670 | 508 |
| always | 67.5 | 407 | 700 | 610 | 532 |
| under | 67.5 | 480 | 475 | 530 | 545 |
| mother | 67 | 1945 | 818 | 423 | 249 |
| Word | SFI | Frequency per Million | | | |
| Grade 1 | Grade 4 | Grade 7 | Grade 10 |
| children | 66.8 | 439 | 440 | 437 | 387 |
| enough | 66.7 | 295 | 565 | 514 | 473 |
| together | 66.7 | 279 | 494 | 525 | 507 |
| almost | 66.5 | 176 | 428 | 453 | 470 |
| father | 66.4 | 990 | 813 | 458 | 266 |
| against | 66.3 | 73 | 357 | 421 | 459 |
| young | 66.3 | 157 | 464 | 503 | 449 |
| name | 65.9 | 635 | 420 | 356 | 383 |
| ever | 65.9 | 299 | 555 | 444 | 350 |
| today | 65.8 | 457 | 372 | 368 | 367 |
| upon | 65.7 | 34 | 175 | 359 | 467 |
| word | 65.5 | 228 | 359 | 410 | 394 |
| across | 65.5 | 255 | 465 | 440 | 378 |
| himself | 65.3 | 265 | 393 | 367 | 341 |
| behind | 64.4 | 278 | 414 | 308 | 245 |
| cannot | 64.3 | 225 | 184 | 234 | 273 |
| although | 64 | 3 | 74 | 195 | 285 |
| above | 64 | 82 | 231 | 301 | 300 |
| perhaps | 63.8 | 30 | 199 | 250 | 277 |
| themselves | 63.8 | 24 | 120 | 243 | 290 |
| either | 63.6 | 61 | 156 | 195 | 242 |
| already | 63.6 | 114 | 210 | 244 | 245 |
| quite | 63.4 | 35 | 216 | 246 | 243 |
| rather | 63.3 | 15 | 112 | 167 | 234 |
| below | 63.2 | 63 | 192 | 274 | 229 |
| question | 62.5 | 35 | 140 | 158 | 188 |
| friend | 62.4 | 427 | 234 | 175 | 126 |
| itself | 62.4 | 21 | 97 | 148 | 192 |
| child | 62.4 | 70 | 151 | 164 | 158 |
| shall | 62.3 | 62 | 132 | 122 | 138 |
| necessary | 61.6 | 1 | 26 | 94 | 166 |
| letter | 61.5 | 137 | 157 | 128 | 144 |
| whose | 61.2 | 9 | 49 | 120 | 144 |
| yourself | 60.9 | 96 | 150 | 137 | 133 |
| knowledge | 60.8 | 1 | 17 | 75 | 130 |
| herself | 60.7 | 152 | 187 | 149 | 112 |
| beyond | 60.6 | 5 | 63 | 122 | 129 |
| according | 60.5 | - | 16 | 78 | 137 |
| afternoon | 59.8 | 99 | 183 | 115 | 83 |
| paid | 59.8 | 30 | 62 | 74 | 107 |
| beside | 59.4 | 97 | 153 | 103 | 74 |
| neither | 59.1 | 13 | 52 | 88 | 95 |
| myself | 59 | 142 | 127 | 91 | 77 |
| receive | 58.3 | 1 | 25 | 57 | 81 |
| Word | SFI | Frequency per Million | | | |
| Grade 1 | Grade 4 | Grade 7 | Grade 10 |
| quick | 58.2 | 61 | 77 | 70 | 55 |
| beneath | 57.9 | 3 | 51 | 79 | 80 |
| character | 57.6 | 1 | 20 | 40 | 66 |
| tomorrow | 57.1 | 131 | 105 | 37 | 19 |
| spirit | 56.7 | 6 | 29 | 37 | 48 |
| lord | 56.7 | 20 | 39 | 50 | 41 |
| ought | 55.9 | 14 | 53 | 38 | 34 |
| blind | 55.7 | 19 | 34 | 38 | 32 |
| ourselves | 55.7 | 3 | 22 | 32 | 42 |
| tonight | 55.2 | 97 | 73 | 27 | 12 |
| immediate | 54.7 | - | 2 | 12 | 23 |
| receiving | 52.9 | - | 6 | 14 | 20 |
| altogether | 52.8 | - | 9 | 23 | 18 |
| afterward | 51.9 | 3 | 13 | 19 | 19 |
| perceive | 49 | - | - | 2 | 7 |
| declare | 48.9 | - | 3 | 7 | 6 |
| yourselves | 45.1 | 1 | 5 | 3 | 2 |
| oneself | 45 | - | - | 2 | 4 |
| conceive | 44.7 | - | - | - | 2 |
| braille | 43.9 | 1 | 2 | - | - |
| declaring | 43.4 | - | - | 1 | 2 |
| deceive | 42 | - | - | 1 | 2 |
| perceiving | 41.5 | - | - | 1 | 2 |
| rejoice | 41.4 | - | 1 | 1 | 2 |
| rejoicing | 41.3 | - | - | 1 | 2 |
| thyself | 39.8 | - | - | - | - |
| deceiving | 37.4 | - | - | - | - |
| conceiving | 36.4 | - | - | - | - |

The second part of research question 1 related to whether there were longer, more frequent words that could be represented in braille to improve efficiency. Efficiency was defined as the combination of a word’s length and a word’s SFI (see Table 2). Shortform words were not included in this calculation. Alternate words were identified, by the computer program, for twenty-eight wordsigns. Table 3 shows the efficiency index for these 28 wordsigns and the selected alternate words.

Table 3

*Efficiency Index for Braille Wordsigns and Alternate Words*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Word | Efficiency Index |  | Alternate word | Efficiency Index |  |
| it | 1.51 |  | is | 1.53 |  |
| where | 1.51 |  | when | 1.59 |  |
| these | 1.64 |  | they | 1.73 |  |
| father | 1.48 |  | first | 1.57 |  |
| world | 1.42 |  | water | 1.52 |  |
| question | 1.60 |  | questions | 1.76 |  |
| part | 1.26 |  | place | 1.43 |  |
| will | 1.50 |  | would | 1.69 |  |
| work | 1.32 |  | will | 1.50 |  |
| young | 1.31 |  | your | 1.50 |  |
| here | 1.25 |  | he | 1.46 |  |
| day | 1.17 |  | down | 1.39 |  |
| those | 1.41 |  | things | 1.63 |  |
| cannot | 1.37 |  | called | 1.69 |  |
| rather | 1.32 |  | remember | 1.65 |  |
| so | 1.20 |  | said | 1.53 |  |
| name | 1.13 |  | number | 1.47 |  |
| go | 1.00 |  | good | 1.34 |  |
| us | 0.94 |  | used | 1.33 |  |
| upon | 1.12 |  | usually | 1.61 |  |
| whose | 1.05 |  | what | 1.54 |  |
| shall | 1.11 |  | should | 1.60 |  |
| ever | 1.13 |  | example | 1.65 |  |
| word | 1.12 |  | without | 1.67 |  |
| child | 1.11 |  | children | 1.82 |  |
| ought | 0.78 |  | outside | 1.49 |  |
| lord | 0.66 |  | little | 1.67 |  |
| spirit | 0.98 |  | something | 2.03 |  |

**Research Question 2**

Using the order of introduction from *Building on Patterns* and the log of rank frequency, we found that, especially in Grade 1 and Grade 2 *Building on Patterns*, many words being taught were not a fit in relation to their frequency in 3rd and 4th grade textbooks. For the purpose of this presentation, only results from the analysis of second grade are shown to represent the area of most discussion (see Table 4). Results of the kindergarten and first graded analyses are available from the authors.

Table 4

*Rank Frequency of Braille Characters in the Order Taught: Second Grade*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Order in BOP | Word | Rank Frequency | Groupsign | Rank Frequency |
| 1 | between | 322 |  |  |
| 2 |  |  | gh | 177 |
| 3 |  |  | bb | 527 |
| 4 |  |  | cc | 579 |
| 5 |  |  | ff | 284 |
| 6 |  |  | gg | 414 |
| 7 | according | 3406 |  |  |
| 8 | herself | 486 |  |  |
| 9 | itself | 968 |  |  |
| 10 | oneself | --- |  |  |
| 11 | thyself | --- |  |  |
| 12 |  |  | less | 826 |
| 13 |  |  | ful | 796 |
| 14 |  |  | ity | 453 |
| 15 |  |  | ence | 816 |
| 16 | declare | 7112 |  |  |
| 17 | declaring | 12996 |  |  |
| 18 | perhaps | 512 |  |  |
| 19 | afterward | 3406 |  |  |
| 20 |  |  | con | 198 |
| 21 |  |  | dis | 355 |
| 22 |  |  | be | 110 |
| 23 | behind | 249 |  |  |
| 24 | below | 472 |  |  |
| 25 | beneath | 1531 |  |  |
| 26 | beside | 585 |  |  |
| 27 | beyond | 1289 |  |  |
| 28 | above | 429 |  |  |
| 29 | altogether | 4509 |  |  |
| 30 |  |  | ong | 512 |
| 31 | although | 1188 |  |  |
| 32 | immediate | 9142 |  |  |
| 33 | necessary | 2317 |  |  |
| 34 |  |  | ance | 717 |
| 35 |  |  | ness | 377 |
| 36 | rejoice | 11601 |  |  |
| 37 | rejoicing | 12996 |  |  |
| Order in BOP | Word | Rank Frequency | Groupsign | Rank Frequency |
| 38 |  |  | ound | 693 |
| 39 |  |  | ount | 1088 |
| 40 |  |  | ment | 387 |
| 41 | conceive | 12996 |  |  |
| 42 | conceiving | --- |  |  |
| 43 | deceive | 12996 |  |  |
| 44 | deceiving | --- |  |  |
| 45 | perceive | --- |  |  |
| 46 | perceiving | 12996 |  |  |
| 47 | receive | 2514 |  |  |
| 48 | receiving | 5912 |  |  |
| 49 |  |  | tion | 135 |
| 50 |  |  | sion | 731 |
| 51 | ourselves | 2661 |  |  |
| 52 | themselves | 807 |  |  |
| 53 | yourselves | 5614 |  |  |

**Discussion**

Overall, braille contractions are a generally strong representation of printed English. There was good representation within the 50 most frequent words, and our efficiency index showed that wordsigns and initial-letter contractions were already extremely efficient.

**Alternate Wordsigns**

The majority of identified alternates were already represented in braille. One is an alphabet wordsign, some (n=8) are shortform words, some (n=11) contain one contraction already, and others (n=3) contain more than one contraction. Our analysis revealed only five wordsigns with more efficient alternates that were not already represented in braille. The program suggested replacing: 1) *it* with *is*, 2) *part* with *place*, 3) *here* with *he*, 4) *upon* with *usually*, and 5) *ever* with *example*. For some of these suggestions, there are uses which a computer program cannot account for. For the word *it*, rules about alphabet wordsigns allow us to use the contraction *it* for *it’s* and *its*, which increases the frequency of its use. There is no nominalization for the word *is* and so its use would be more limited. For the word *here*, the initial-letter contraction is a two-cell contraction so replacing *here* with *he* would not save any space because it would be replacing two cells (h-e) with two cells (dot 5-h). For the word *ever*, rules for the use of initial-letter contractions allow us to use the letters e-v-e-r when they appear in other words as long as the first *e* is stressed and the letters are not preceded by *e* or *i*. These rules increase the frequency of the contraction *ever* and make it more efficient than the word *example*, which has more limited appearances. Ultimately, the more efficient alternates suggested by the program are only more efficient if looked at in isolation of the rules of UEB.

**Order of Instruction and Implications for Teaching Shortform Words**

We expected there to be some mismatch between the order of introduction and frequency when considering that *Building on Patterns* is a K-2 curriculum and we looked at frequency in 3rd and 4th grade textbooks. However, we would hope that words being learned in earlier grades would be frequent in later grades. That was not the case. Specifically, we found certain shortform words that never appeared in 3rd or 4th grade texts of the EWFG (i.e., oneself, thyself, conceiving, deceiving, perceive).

Even when teachers of students with visual impairments (TVIs) are working in inclusive settings, and may not be using *Building on Patterns,* we have set up in our minds that students learning braille from Pre-K need to learn all the contractions by the time they are in 3rd grade. We have done this so that students have a strong foundation in the braille code before 4th grade when the focus of literacy instruction switches from “learning to read” to “reading to learn”. This provides context for our findings and helps explain why TVIs pair letters and the alphabet wordsigns in their instruction, even when some of the alphabet wordsigns are infrequent (especially in early elementary). There is also a disability-specific rationale for introducing words such as *blind* and *braille* in early elementary, even though these words are infrequent. Even when considering some of the less frequent contractions (e.g., ought, lord, spirit) there is a clear link to the reading of the Bible and the 19th century origins of the braille code.

However, when looking at the results of the order of introduction analysis in the context of research question 1 (How frequently do words represented with contractions occur in print and does this reflect the frequency of words in printed English?) a pattern became very clear. Of the 50 least frequent words represented in braille (see Table 2), 40 are shortform words. Looking at Table 4, it is also clear that the order of introduction for many of the shortform words is not a good fit with their frequency of occurrence in print. The reason we want to highlight this in our discussion is because shortform words are very different from other contractions when considering their form.

According to the terminology of the Rules for Unified English Braille (2013), a shortform word is, “a contraction consisting of a word specially abbreviated in braille”. The abbreviated nature of a shortform word is what makes it different in form from other contractions. For instance, when encountering the *gh* groupsign for the first time a skilled reader may be able to identify it based on context – but if no context is provided, the braille character (represented by dots 1-2-6) is unique and abstract, bearing no clear resemblance to the letters it represents. However, shortform words are not unique in the sense that they bear a resemblance to the words they represent. As a general rule, shortform words do not contain any vowels (unless it is part of a contraction, as in the shortform for *perhaps*). One of the first rules of spelling children learn is that every word has at least one vowel. Therefore, if a child learning braille encounters a word with no vowels, even out of context, they can be fairly certain it is a shortform word. The Extending this logic further, the general abbreviating of a shortform word could be applied to other words. For example, I could represent the word *best* with the letters *bst* and it would follow that the reader would understand that a vowel had been omitted and, using context clues and the likeliest possible choice, read *bst* as the word *best*.

Without going too far toward the hypothetical, shortform words closely resemble spelling or grammatical rules (e.g., i before e except after c). The rule can be learned and then broadly applied, rather than memorized as a list of words. Our results show that shortform words taught in second grade may never appear in a textbook during the entire K-12 experience. It seems to make more sense to teach the terminology; that shortform words are abbreviated. TVIs would still teach many of the shortform words explicitly, as there are many frequent shortforms (e.g., good) and this would provide a meaningful foundation for strategies to read new shortform words that may not have been taught explicitly (e.g., oneself).

Ultimately, we found that braille tends to be a close and efficient representation of printed English when considering the frequency of words, but that braille instructional practices could be refined to support earlier acquisition of important features of English. Specifically, we feel that certain shortform words do not need to be taught explicitly in early elementary school, especially if the general principle of shortform words is understood.

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