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Analysis of the Length of Braille Texts in English Braille American Edition, the Nemeth Code, and Computer Braille Code versus the Unified English Braille Code

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Abstract: This study compared the length of text in English Braille American Edition, the Nemeth code, and the computer braille code with the Unified English Braille Code (UEBC)--also known as Unified English Braille (UEB). The findings indicate that differences in the length of text are dependent on the type of material that is transcribed and the grade level of the text. The greater length of text in UEBC was most evident in spatial arithmetic and algebra.

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This article is the second of three research articles that address the implications of adopting the Unified English Braille Code (UEBC)--also known as Unified English Braille (UEB). An earlier article (Wetzel & Knowlton, 2006) presented the opinions of focus groups composed of teachers, transcribers, and users on their perceptions of UEBC and its impact on their work. It ended with suggestions for future research on the production and learning of braille. The purpose of the current article is to present some comparisons of braille transcription and production in the current codes of the English Braille American Edition (EBAE), the Nemeth code, and the computer braille code (CBC) with UEBC. This report begins with a list of research questions that were presented by the Braille Authority of North America (BANA) that were relevant to the length of braille transcriptions. Following this list is a brief description of the structure of the research and the findings. The article ends with suggestions for avenues for further research that may help direct future decisions regarding UEBC.

UEBC presents a system in which print symbols maintain the same form in braille regardless of the type of material that is being transcribed. To do so requires several minor changes to EBAE. In brief, the alphabetic letters are maintained, but six contractions (*ally, ation, dd, to, into*, and *by*) are no longer used. Changes for the use of the *in* contraction in *into* and the *tion* contraction in *ation* are also made. Changes to the Nemeth code and CBC for mathematics are much more substantial, and not all of them can be addressed here. The reader is referred to the UEBC web site <www.iceb.org/ubc.html> for more detailed information. Briefly, UEBC requires double-cell signs for all signs of operation and most signs of comparison. Signs of grouping are two or more cells in length. In addition, all numerals are in the upper-cell position, which requires the insertion of numeric or alphabetic indicators when changing from one intended meaning to the other. Spacing before and after signs of operation was initially required, but a change adopted in 2004 leaves this spacing to the discretion of the transcriber.

The research questions that BANA proposed with regard to the length of text included the following:

1. How will the implementation of UEBC affect the reading rates, fluency, and proficiency of readers of current codes?

2. What are the tangible and intangible costs of implementing UEBC, including the cost of transitioning to UEBC and the cost-effectiveness of UEBC compared with the current codes?

3. What are the effects of extra symbols, spaces, and pages that may occur with UEBC compared with the current codes?

4. What is the effect of UEBC on production issues, such as writing or computer embossing, in terms of time necessary, the amount of paper required, and the number of volumes that are needed compared with the current codes?

An earlier report (Wetzel & Knowlton, 2006) addressed the opinions of teachers, transcribers, and braille users about the adoption of UEBC. An issue that the focus-group members raised during that study was that UEBC requires more cells, more pages of text, and more volumes than do EBAE and the Nemeth codes. If braille transcriptions in UEBC require more pages and more volumes, the costs of production would be higher, since the cost of braille is frequently computed by the number of braille pages in a document or publication. Sample texts were analyzed to address this concern.

Text analysis

PROCEDURES FOR DATA COLLECTION

This project began by examining the BANA publications *BANA UEBC Sampler 1* (2001) and *BANA UEBC Sampler 2* (2001), as well as the web site of the International Council on English Braille, <www.iceb.org/ubc.html> for current information related to UEBC. Nine text samples of UEBC, EBAE, Nemeth code, and CBC were identified and analyzed. In selecting the text samples, we limited the materials to elementary or secondary school content, since braille may be introduced at any age due to changes in visual abilities of the student. For each sample, we computed the text length in braille cells and noted the comparative length of the material in EBAE, Nemeth code, and CBC versus UEBC. Two samples each of arithmetic, algebra, and computer text were taken from the *BANA UEBC Sampler 2*. See Table 1 for a summary of this information.

The first arithmetic sample (the print form on p. 9 of the *BANA UEBC Sampler 2*) consists of a set of spatial arithmetic problems, including examples of addition, subtraction, and multiplication containing a total of 403 print characters. The second arithmetic sample (the print form on p. 183 of the *BANA UEBC Sampler 2*) consists of 8 problems in basic arithmetic that are displayed in linear fashion and includes examples of addition, subtraction, multiplication, and division containing a total of 404 print characters. The first algebra text selection (the print form on p. 57 of the *BANA UEBC Sampler 2*) consists of 30 algebra problems and requires 722 print characters. The second algebra selection (the print form on pp. 59-60 of the *BANA UEBC Sampler 2*) includes 50 problems that are presented for factoring and requires 1,191 print characters. Two samples of a computer program were also selected from the sampler. The first (on p. 224 of the *BANA UEBC Sampler 2*) requires 17 lines and has 511 print characters, and the second (on p. 231 of the *BANA UEBC Sampler 2*) requires 13 lines and has 400 print characters.

Finally, samples of literary text were selected from three popular children's books. They included approximately three print pages each of text from *Charlotte's Web* by White (1952, pp. 8-10), *On the Shores of Plum Creek* by Wilder (1937, pp. 22-24), and *Quidditch Through the Ages* by Rowling (2001, pp. 1-3). These samples require 1,840-2,095 print characters each, with a mean of 2,000 print characters (see Table 2).

Analyses of the arithmetic, algebra, and computer samples were done using the *BANA UEBC Sampler 2* simulated braille transcription in the Nemeth code and UEBC. The selected literary samples were transcribed by hand into EBAE code and UEBC for comparison. Comparisons were made of character or cell counts, lines, and line wraps that are required when transcribing the selections from print into braille. Line wraps were defined as situations in which the spatial format of a math expression exceeded 41 cells and thus required a runover on the next braille line. As can be seen from this analysis, the impact of UEBC versus EBAE, Nemeth code, and CBC varies, depending on the type of text being transcribed. Modest increases in text length of 4% to 7% result when using UEBC, rather than EBAE, for the literary text. The third sample, from *Quidditch Through the Ages*, presents the greatest difference between the two codes. This text is at a higher grade level, so that the eight contractions that were dropped from EBAE may occur more frequently than in the other two literary text selections.

RESULTS OF THE TEXT ANALYSIS

The text comparison of EBAE, Nemeth code, and CBC code with UEBC yielded the results presented in Table 1. The increase or decrease in the total cell count for each selection was computed. The findings indicate that spatial arithmetic, as presented for calculation, requires 21.9% more cells in UEBC than in the Nemeth code. However, for linear expressions, there is only a 1% increase. UEBC transcriptions for the two algebra samples are 54.8% and 46.2% longer than those for the Nemeth code, and the two CBC samples are -4.5% and +1.1% longer in UEBC than in the Nemeth code. The three sections of literary text are 4.2%, 4.1%, and 7.0% longer.

A new change in the rules for UEBC regarding rule spacing with signs of operation was made after the first data analyses of this study were computed. The new rule leaves spacing before and after signs of operation to the discretion of the April 7, 2006 transcriber. Since the use or nonuse of spacing in these circumstances is optional, the character or cell counts were recalculated to present results reflecting this change. Table 3 presents the data for the arithmetic and algebra sections with spacing eliminated in these situations. This change does not affect the computer or literary selections.

Deleting the spaces before and after signs of operation in UEBC selections of arithmetic and algebra significantly reduces the length of the sample. In this case, the increase in the length of text in the linear arithmetic sample between the Nemeth code and UEBC was nonsignificant, but in the spatial computation format, there was still a 17.1% increase in the transcription length of UEBC compared to the Nemeth code. In the case of algebra, use of the rule change reduced the text length by 19.7% for UEBC transcriptions if the spaces were deleted, but the selections were still 20%-35% longer than the same samples in the Nemeth code.

A final analysis of two longer sections of text was made to compare the Nemeth transcriptions with UEBC transcriptions. Full chapter sections of algebra and calculus, presented in the *BANA UEBC Sampler 2*, were analyzed for text length when translated into the two codes. The criteria for the inclusion of these chapters in the *BANA UEBC Sampler 2* could not be determined. However, we decided to include them for analysis, since they constituted lengthier examples of algebra and calculus text. The findings for the print text (on pp. 56-65, in sections labeled 3-4 to 3-7 only), the Nemeth code text transcription (on even pp. 68-120), and UEBC transcription (on odd pp. 69-121) are presented in Tables 4 and 5. The total number of lines in each chapter section were counted in both the Nemeth code and UEBC. The number of braille pages were calculated assuming a 25-line braille page. A ratio of print page to braille page was calculated as a measure of the expansion of text. The *UEBC Sampler 2* transcriptions do not include any code changes made after June 2001, so no analysis was made using these changes.

For the algebra chapter section (see Table 4), the 9.2 pages of print text require 128 more lines and 5.2 more braille pages in UEBC than in the Nemeth code. This is a 25% increase in braille lines and, consequently, a 25% increase in braille pages compared to the Nemeth code transcription, which would result in a 25% increase in the number of volumes required. Considering these findings with regard to an algebra book of 677 print pages transcribed into the Nemeth code by the Communication Center of the Minnesota State Services for the Blind, we found that the Nemeth code transcription actually required 2,480 braille pages bound into 41 volumes. The average cost per braille page at this agency is $5.40. This rate is an average rate based on all braille produced by this agency, not just mathematical or technical materials. The total cost for this Nemeth code algebra text was $13,392. Assuming a 25% increase in braille pages if the book were to be translated into UEBC, the same book would require 620 more pages, equivalent to 10 more volumes, with an increased cost of $3,348. Hence, the total hypothetical cost for the same book in UEBC is estimated to be about $16,740 for 51 volumes.

A similar analysis was conducted for a sample of calculus presented in the BANA *UEBC Sampler 2* (on print pp. 124-133; see Table 5). As with the algebra text selections, the Nemeth code transcription is on even pages (pp. 134-174), and UEBC transcription is on odd pages (pp. 135-175). The braille transcriptions of both the Nemeth code and UEBC do not include the eight diagrams that are presented in the print copy. The number of print pages for this sample was recalculated as text only, without diagrams, to be more closely compared to the simulated braille samples.

For the chapter section of calculus, UEBC transcription is 8.25% longer than the Nemeth code transcription when analyzed without the inclusion of text diagrams. A Nemeth code transcription of a calculus book that is currently in production is estimated to cost approximately $44,000. Transcription with

UEBC could be projected to cost an additional 8.2% ($3,608), making the total cost of the book $47,608, assuming that the diagrams for the Nemeth code and UEBC transcriptions require the same number of pages.

We acknowledge that the costs of braille transcription are set by the individual agencies and may vary greatly from one agency to another. It is also true that the accuracy and clarity of the braille format varies from agency to agency. The figures presented here are but two examples for the comparison of real costs and projected cost increases if UEBC is adopted.

Limitations

Further research is needed in this area before we can definitively state the true differences in the transcription costs of the two codes. It is obvious that there is a wide range of variability in the length of text, depending on the subject matter being transcribed. There are also indications that the complexity of the text and the intended grade level of the material may contribute to this variability. It is also possible that there are additional factors that have not yet been identified, including different pricing rates by different agencies and different sources of subsidies for braille production.

How the greater length of braille text precisely affects reading efficiency, production time (transcription, materials, printing time, and binding), and the ultimate cost of braille books requires further study. When one looks at the increased number of characters that are needed to represent a particular passage in UEBC, it becomes apparent that even for the accomplished braille reader, it may take much longer to read the material in some instances because of the greater number of pages and volumes. At higher levels of mathematics (calculus and computer programming), the two codes seem to be more equivalent in length. The greatest differences occur in basic arithmetic calculation and algebra.

This study did not address the reading and transcribing of graphic material, tables, maps, or diagrams. This area is a substantial component of many technical books and needs serious consideration. The greater text length in UEBC may require additional spaces for labels or more extensive keying of charts, diagrams, and maps to fit a single graphic on a page.

The analysis of text samples of EBAE, the Nemeth code, and CBC versus UEBC revealed that changes in the total length of text varied greatly with the type of text that was being compared. UEBC presented the largest increases in the basic arithmetic computation format (21%) and algebra (46%-54%). Even when we took the new UEBC spacing rules into consideration, arithmetic computation still required 17% more characters and algebra required 20%-35% more characters. Computer samples indicated little difference between CBC and UEBC. Extra line wraps can only partly account for the increase in the length of text. In contrast, basic literary text for material at the fourth-grade level is 4%-7% longer in UEBC.

Since the cost of braille is often assessed as a set fee per braille page, it is likely that a longer text length will raise the cost of braille in a comparable manner. A hypothetical (10%) increase in the number of lines would result in an increase of 10% in pages, in braille volumes, and in production costs. As has been noted, the proposed 10% increase is not equal across all texts. Some types of text (such as algebra) would generate a much greater increase in UEBC than would others, such as computer programs.

Implications for future research

The findings from other areas of study could assist and guide decision making regarding changes to braille codes. To date, no studies have addressed the transcription and comprehension of graphic material in braille. The fields of geometry, trigonometry, and calculus rely heavily on graphics. Maps, charts, graphs, and diagrams also encode information in a manner that requires the use of lines, points, and areas, as well as text for labeling significant parts. A unified code needs to address this kind of information in addition to pure literary text.

Writing braille is an area of research that is yet to be addressed. The use and nonuse of contractions and spacing may affect the efficiency of writing, and the increased number of cells may decrease the efficiency of the manipulation of text and mathematical calculation. The manipulation of text includes the activities of the user in editing or amending literary text, solving arithmetic problems, and constructing and solving computer programs. There may also be limits related to memory load and the attention required for this kind of text manipulation.

Perhaps some of the most significant research on any braille code needs to address a vast array of cognitive issues that are related to learning and using braille as a reading and writing system. The field would benefit from studies that address the limits of short-term memory (working memory) as they apply to the reading, recall, and writing of braille. The limits of short-term memory are acknowledged to be at a level of 7 ± 2 items (or bits) of information (Kalet, 2005). Certain common mathematical notations easily exceed this limit in UEBC in absolute cell counts. At this time, it is not known if there are higher-order units of memory encoding that would be larger than a single cell. This limit may affect the ability not only to learn and remember information accurately, but to manipulate it in problem solving. Finally, research needs to address the learning curve as individuals of all ages learn to read and write braille. Such studies would greatly inform professionals as we make decisions that affect students of braille and provide them with access to diverse sorts of information.

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