Multi-Line Braille Displays: So What?

Considering the practical use and ongoing development of multi-line braille displays from a user perspective

Matthew Horspool: Freelance braille and assistive technology consultant

161, Cheveral Avenue, Radford, Coventry, CV6 3HD, United Kingdom

+44(0)7429 171736

mhorspool@live.co.uk

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# Abstract

Over the past few years, the momentum surrounding multi-line braille displays has increased substantially, from both manufacturers and end users. However, as a blind person myself, my excitement about the concept of a multi-line braille display is juxtaposed by an increasing realisation that I am not currently interested in buying one!

This paper will explore the reasoning behind this juxtaposition and, in doing so, it will consider the following questions:

* Are manufacturers trying to solve the right problem?
* Are multi-line braille displays always the best solution?
* How can multi-line braille displays evolve to meet more user needs more effectively?
* What other developments are required to ensure that multi-line braille displays reach their full potential?

Whilst this is first and foremost an opinion paper, my training and consultancy work and my involvement with UKAAF and the Braillists Foundation has immersed me in a wide variety of user and professional responses to multi-line braille displays, and this has been an enormous help in shaping my thinking.

# About the Author

Matthew has been blind since birth and fervently believes that braille is an essential tool for all visually impaired people. He makes extensive use of braille both personally and professionally, and his career spans over ten years in the UK visual impairment sector in roles which bridge the boundaries between braille and technology.

In addition to his freelance work training individuals in the use of screen readers and braille devices, he holds several influential positions including:

* General Manager, The Braillists Foundation
* Braille Subject Lead, UK Association for Accessible Formats (UKAAF)
* Code Maintenance Officer, International Council on English Braille (ICEB)

# Overcoming Challenges of Single-Line Displays

A common narrative around multi-line displays is that they are better simply because they consist of multiple lines. However, I do not believe that this is necessarily the case.

## Limitations of Single-Line Displays

### Displaying tables spatially

If the spatial layout of a table is preserved, only one row can be displayed at a time, which obfuscates the relationship between rows. If the width of data in a column is variable, e.g. some small numbers and some large ones, it can also give the illusion of space being wasted on the display if the row being displayed contains short data.

Furthermore, since braille generally occupies more space than print, a row may not fit on a single display width and may hence need to be divided. A ‘word wrap’ feature prohibits this division from occurring partway through a word, but division partway through a cell is still common.

### Showing indentation in context

Single-line braille displays can show indentation, such as for paragraphs or in programming, on a line-by-line basis. However, without panning, it is not possible to determine whether the indentation is correct or appropriate or, in some cases, what it is intended to show.

### Displaying multiple pieces of information simultaneously

In braille music, “parts” (such as vocal parts or the left and right hands of a piano part) are often shown in ‘parallels’ left aligned to the start of each ‘bar’ or ‘measure’, each “part” underneath the other. Digital braille music is generally stored line-for-line in a text-based file, with no semantic information. Consequently, single-line braille displays present it line by line, with no option to re-order the music to show the parts more intuitively.

In Graphical User Interfaces (GUIs) such as Windows®, a line is generally reserved for the ‘title’ of a window. In addition, some controls (e.g. list boxes) occupy multiple lines; others (e.g. radio buttons) may be grouped together to form a single multi-line set; and others are designed to be used in parallel, e.g. an edit box which updates based on the selection in a neighbouring list box. In cases such as these, without intervention, a single-line display can generally only show the active control or the active line.

Furthermore, many GUIs allow multiple windows to be shown simultaneously, but single-line displays only show the window in the foreground.

### Charts, graphs and images

Although a single-line braille display consists of four lines of dots, users do not typically perceive them as four distinct lines. Furthermore, the spacing is narrow and the shape is rectangular, so it is difficult to display shapes other than rectangles and squares.

Consequently, single-line displays are largely only suitable for displaying text. Users are reliant on descriptions of charts, graphs and images, rather than being able to feel them for themselves.

## Single-Line Workarounds and Solutions

### Table reading

Conventions have emerged which disregard the spatial layout in order to enable readers to associate a cell with its row and column headers. Often, a table is shown one cell at a time, with its headers and/or coordinates occupying the remainder of the display.

Alternatively, an entire row may be shown on the braille display, with a special symbol inserted between columns in lieu of extra space.

If the table is set out spatially in a braille file, and the line length of the file does not exceed the length of the display, the reader may pan up and down the file, leaving one finger on the column of interest. That column will refresh under the reader's fingers and the reader will be able to track the data as it changes.

### GUIs

Many screen readers have a mode which shows multiple pieces of information from a window at the expense of its spatial layout. Examples include ‘Structured mode’ in JAWS® and ‘Logical mode’ in Supernova.

### Split Braille

This is a feature of the JAWS® screen reader which allows a single-line display to be divided into two regions, thus enabling two discrete lines to be displayed at once. The two lines may be in the same window, but do not need to be.

The ‘Buffered Text’ view allows a file to be shown in the second region. If the same file is shown live in the first region, with the buffer one line ahead, the reader can move by two lines at a time in each region in order to read two lines of the same file simultaneously. This is effective in showing music parallels comprised of two lines, but falls short if the parallel is larger.

Furthermore, the Split Braille feature prioritises multiple pieces of information at the expense of line length, which limits its scalability.

### Displaying shapes

Rectangles and squares are useful shapes. For example, progress bars can be formed from full and half cells.

Circles and other primitive shapes can also be conveyed effectively. However, these shapes are not entirely accurate and the technique is therefore only effective if the shapes are small.

### Graphs

It would be possible to display bar graphs on a single-line braille display using full and part cells, but I have not seen this adopted in any braille or screen reading products.

The KeyMath application on the BrailleNote Touch Plus from HumanWare can generate graphs of equations. A tactile preview mode divides these graphs into logical “lines”, each “line” representing a value on the y axis and conveying a representation of what would be shown on graph paper at that point. This feature has had little exposure and limited training is available in its use, which has restricted its potential.

## The Remaining Impact

For print users, there is a parallel between the content which can be displayed on a monitor and that which can be printed on a page. There is no equivalent for braille users aside from multi-line displays, and this is a key selling point for manufacturers.

Several use cases for multi-line braille immediately spring to mind, including column addition, frequency tables, results tables for experiments, and charts and graphs. These are mostly centred around the Science, Technology, Engineering, Mathematics and Medicine (STEMM) fields. This has a disproportionate impact on education, where there is often a legal requirement to teach STEMM subjects up to a certain level.

Parenthetically, it should be noted that tactile graphics displays can show charts, graphs and images, whereas multi-line braille displays cannot. Manufacturers are nonetheless marketing attempts to render graphical content using braille dots, but the efficacy of this approach is unknown.

Outside the STEMM fields, content is generally either linear text already or can be conveyed satisfactorily in a linear text format. There is a significant amount of spatial or graphical data in the business world which would suit multi-line technology, but such material is generally only conveyed spatially or graphically for the sake of convenience, and with due consideration it can be presented linearly or numerically instead.

I would therefore argue that, on balance, the impact of the limitations of single-line displays is fairly small.

# The Role of Hard Copy Braille

Hard copy is one solution to the remaining limitations of single-line displays. However, reverting to hard copy to access spatial or graphical content is either inconvenient already, or will become inconvenient in the future.

## Reasons for Retention

### Perceived advantage

Some readers will always have a preference for hard copy. In some cases, this may be borne out of perception rather than actuality. For example, it is theoretically much quicker to locate information in an index from a digital copy than from a hard copy, but this assumes that the user is comfortable locating the digital file and searching through it.

### Learning braille

Learning to use braille technology may provide a distraction from learning the braille code itself. Furthermore, braille displays typically require a basic knowledge of braille in order to operate them, since their menus and status messages are displayed solely in braille, so it may not be viable to introduce them immediately.

### Personal or sentimental value

We often attach greater value to certain items, e.g. greetings cards and certificates, when they are presented physically.

### Not susceptible to technical error/oversight

Hard copy documents cannot become corrupt, and will never have a flat battery! For this reason, many people still prefer to use hard copy for critical applications such as maintaining an emergency contacts list and preparing notes for public speaking.

### Proximity

Some information benefits from appearing in hard copy alongside the object or activity to which it relates. Examples include signage, information about museum exhibits and appliance cheat sheets.

## Factors Impacting its Uptake

### Cost

Hard copy production requires the use of specialist equipment and consumables, which are expensive to procure and maintain. The equipment may also require the operator to possess specialist knowledge and skills, resulting in higher training and salary costs.

### Size

Braille books often need to be divided into several volumes, each volume occupying more space than the entire print book. This makes them difficult to store and impacts how they can be transported, which in turn elevates the level of forward planning required by braille readers and the people working with them.

Furthermore, without free post for the blind schemes, the cost of transporting braille books between readers and producers or libraries would be prohibitive.

### Environmental impact

Braille books do not contain ink, and the paper is therefore inherently recyclable. However, this is often not the case for the binding materials, and the quantity and density of paper is higher. The environmental impact of braille books is therefore still quite high, and the perception is even higher.

### Dots wear out

This is a particular consideration for new braille readers, but even advanced readers may struggle if the dots are particularly faint or uneven. This necessitates the re-embossing of books from time to time in order to maintain an acceptable dot quality.

### Production time

Many people do not have access to the specialist equipment required to produce braille books. Even for those who do, the equipment cannot produce books instantaneously. This means that braille may not be available if it is required at short notice.

# Multi-Line Displays: Benefits, Challenges and Future Developments

A number of factors continue to limit the success of multi-line displays, and there are several things which the manufacturers themselves and supporting third-parties could implement in order to make them more successful.

## User-Cited Factors Against Multi-Line Displays

### Cost

The headline costs of tactile graphics displays are in excess of $10,000 USD, which is much higher than the cost of single-line products. However, multi-line braille displays which cannot render graphics are considerably cheaper at around $3-4000 USD, which is in line with, and sometimes cheaper than, the cost of single-line products.

Since more expensive single-line products remain popular, I do not believe that the price point of multi-line displays is a particular concern.

### Portability

Although multi-line braille displays are smaller than the volumes of braille they are designed to replace, they are still larger than print books, and substantially larger than single-line displays. This is exacerbated by the line spacing on some multi-line displays, which is wider than the spacing on paper. Moreover, some displays, such as the Canute 360, do not incorporate a battery, so they cannot easily be used away from home even in relatively static environments such as conference rooms or places of worship.

The size of a single-line display is much more in line with the size of a print book, which makes single-line displays more desirable in many cases.

### Compatibility

This has a number of permutations:

* many multi-line displays do not support common file formats such as Microsoft Word®, PDF or EPUB;
* many multi-line displays cannot interface directly with online libraries; and
* many screen readers do not support multi-line displays.

### Refresh rate and loudness

Multi-line displays are at most only marginally louder than many other background noises such as typing or printing, and I do not believe that they will provide much real world distraction. However, users who have prior experience of single-line piezoelectric displays are likely to notice the increased loudness, resulting in poor initial impressions of multi-line displays.

Prolonged use may redress this in many situations. However, current multi-line displays are likely to be unsuitable where background noise is not appropriate, such as broadcast or voiceover work.

Refresh rates vary between displays and are also likely to be noticed most keenly by users of piezoelectric displays. Aside from this, the impact of the slower refresh rate depends upon the user's reading speed, the nature of the content being read and the refresh style employed by the display. For example, if the content is spatial, displays which refresh line by line are likely to be less suitable than those which refresh all lines simultaneously.

## Design Considerations for Manufacturers

### Feature parity with single-line displays

Users of single-line displays have become accustomed to being able to:

* browse a file system containing both files and folders;
* jump to a file or folder by typing its initial letter;
* move, copy, rename and delete files and folders on the device;
* search for text within an open file;
* create, and return to, named bookmarks;
* access online libraries directly from the display;
* perform firmware upgrades directly from the display via the internet.

A multi-line display which does not incorporate these features is likely to be perceived as a downgrade over a single-line display.

### Composition and editing functionality

A keyboard is necessary for the implementation of some of the features discussed above, and could also be used for the composition and editing of files.

Users might like to compose content directly on a multi-line display if it is spatial in nature or if the display is being used in a fast-paced environment such as a classroom.

Editing existing content would be desirable, for example, if a user is presented with an incomplete table to be completed in a meeting and wishes to access the table on a multi-line display.

Some multi-line displays only have six-dot cells, which is problematic for editing because there is an established convention of showing the cursor using dots 7 and 8. An alternative means of showing the cursor will need to be devised for these displays, possibly involving using the line below, although this would reduce the amount of data which could be shown.

Furthermore, some multi-line displays do not have cursor routing buttons at all, and others only have one line of them. Users will therefore need to adjust to new cursor movement habits.

### Text flow

Many single-line displays do not handle braille files graciously if the line length of the file exceeds the length of the display. For example, lines in the file may be rendered on the display as one long line followed by one short line, with centred lines appearing right justified on the long line and left justified on the short line.

The issue is more complicated for multi-line displays and consequently, in general, I am not confident that they will handle it any better. Text reflowing will likely only be desirable for non-spatial content. For spatial content, especially when it is wide, it may be desirable to create files which have a long line length, in which case it will be necessary to be able to pan left and right as well as up and down.

That said, Orbit Research have overcome this issue on their Orbit Slate line, which has two modes. Flow mode suppresses all line breaks in the file unless they are followed by another line break or white space, and then relies on word wrap functionality to render the content satisfactorily. Windowed mode, on the other hand, shows a display length of each line in the file and allows the reader to pan left and right to show additional content on each line.

### Panning

Multi-line displays can currently advance and revert by the number of lines on the display. However, it would also be useful to be able to pan line by line.

The ability to freeze lines and columns would be an exciting extension to this concept. For example, if a file contains a table, once the column headers are displayed on the top line of the display, it should be possible to set that line to remain in place on the display whenever it is panned. An additional setting could determine whether the frozen lines should be cleared if the display is panned above them. A similar technique could be employed for columns, I.E. when panning across, always show the first x number of characters of each line.

### Focus on core functionality

Multi-line displays are still very much in their infancy, and it is therefore easy to classify them as experimental products. In doing so, there is a risk that functionality such as gaming, which was originally considered secondary, may be prioritised above the original primary functionality. Manufacturers should be vigilant about this and make a conscious effort to avoid it happening.

### Number of lines

A display consisting of two lines would be more useful than a single-line display, and it would also probably alleviate some of the portability concerns with multi-line displays by still being slim enough to sit in front of a computer keyboard. If piezoelectric cells are used, this would also alleviate concerns around refresh rate and loudness.

To this end, I am disappointed that there are no 80-cell piezoelectric displays available which have been configured in two lines of 40 cells. Single-line, piezoelectric 80-cell displays already exist with a loyal market, so it seems reasonable to deduce that a multi-line 80-cell display at the same price point would be viable.

### Proofreading

Multi-line displays could be used by proofreaders to check formatting instead of embossing a proof copy. The Canute 360 can communicate directly with the Duxbury Braille Translator in order to facilitate this, and it would be good if this functionality was also available in other multi-line displays and translation packages.

## Third-Party Improvements

### Transcriber reflowing of content

Combining the individual volumes of a braille book into a single file, as championed by the Royal National Institute of Blind People (RNIB), has been found to be advantageous for braille display users as it makes it much easier to search for content within a book.

In addition, certain formatting choices have been made on the basis that the content will be read in Extensions to this process in specific situations would be welcome. For example, in a song book, the chorus is generally only written after the first verse in order to save space. However, on a braille display, it would in fact be better if the chorus was written after each verse so as to avoid the need to pan back and forth.

### DAISY Braille File Format Working Group

The American Printing House for the Blind (APH) is currently spearheading the creation of a new braille file format standard, known as EBRF (Enhanced Braille Ready Format) or EBraille, under the auspices of the DAISY Consortium. One of the objectives of this standard is to make braille files dynamically reflowable.

Another is to add semantic information to braille files. This will benefit all braille displays, but especially those which do not have input capabilities. For example, the Canute 360 would be able to implement a menu of headings similar to its library menu. It should also make “Go to page” functionality more reliable, as page numbers could be encoded in a uniform way.

### Multi-line braille support in screen readers

We already know that the user experience is very poor if screen readers simply treat a multi-line display as a long single-line display. Proper screen reader support will therefore perhaps be the most significant third-party intervention in terms of improving the usefulness of multi-line displays. It is also undoubtedly the most difficult to design, and various approaches will likely be released before a winner emerges.

When discussing the design of screen reader support, we should consider the importance of rendering text versus establishing context. This may depend on the number of lines available but, for example, developers should research the importance of reserving lines for:

* the title bar,
* the status bar, and
* notifications and status messages.

Additionally, the concepts of panning and text reflowing should also be considered in the design of screen reader support.

# Conclusion

At present, multi-line braille displays have an identity crisis in that they are being marketed as the solution to single-line braille. This lack of purpose is resulting in functionality which is either too primitive or too generic to be useful, relegating the status of multi-line displays to that of a secondary device. Users therefore find it difficult to justify them in funding applications or commit to purchasing them themselves.

Manufacturers should instead design multi-line displays which solve a specific problem in order to make their products truly viable.