The difference between traditional braille embossing and digital braille printing embossing tactile ergonomics

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Abstract:

The preparation of printed material for the visually impaired presents a specialized field in the printing and graphics industry. Until recently, embossing was the leading technology for printing braille; however, in recent years, UV inkjet and digital printing have become more prevalent within the field. This research paper examines the difference in terms of ergonomics and usability between traditional braille embossing and digital printing embossing using inks and how the visually impaired can successfully use them, demonstrating which technology is more effective for this group. By using a specific set of parameters to make comparisons of the braille dots and cells in terms of height, diameter, and the distance between them. These parameters relate to the accessibility according to users' specific requirements, facilitating the reading, identification, and discrimination of the information (text, set of points, illustrations, etc.) for the visually impaired. The paper also addresses the theoretical and practical methodological content using the "design for all" general print products for both visually impaired and normal-sighted people. The author adopted the methods and steps in accordance with ISO standards to analyze the results obtained via the ergonomics-related questionnaire completed by a number of braille users of different ages, which related to the various impacts on their capability of reading texts and illustrations.

Keywords:

Digital Printing, Ergonomics, aesthetic design, normal embossing, braille system, braille tactile, visually impaired people, education, human factors.

ملخص البحث:

إن الاعداد لتقديم مواد مطبوعة بطريقة الطباعة الرقمية للمكفوفين أصبح أحد الامور المهمه التى ينبغي دراستها . وقد اصبحت مؤخرا تكنولوجيا الطباعة البارزه للمكفوفين بطريقة برايل باستخدام احبار النفث الحبري يو في والطباعة الرقمية من أهم الطرق التى أخذت طريقها فى هذا الاتجاه، وتقوم تلك الورقة البحث على عرض الاختلاف الارجنومي الاستخدامى بين بروز الانتاج المعتاد فى النماذج المطبوعة بطريقة برايل التقليدية وبين النماذج المنتجة بأحبار طريقة الطباعة الرقمية للمكفوفين وتأثيره على مدي إدراكهم للعناصر وقدرتهم على القراءة بسهوله بين الطريقتين ، وقد قامت الباحثه بالاستناد على بعض العوامل المساعده لتحليل ذلك لمقارنة بينهما وهي ارتفاع النقط المكونه لطريقة برايل بالطرقتين وعرضها والمسافة بين النقاط وهذه العوامل كانت مؤثرة للتعرف على متطلبات المستخدمين لطريقة برايل وذلك لتسهيل القراءه والتعرف على المعلومات الموجوده لديهم فى المطبوع وتشمل المطبوعات المختلفه (الكتابات ، بعض النقاط التى تشير لبعض العناصر ، بعض الرسومات ....الخ) للمكفوفين

وتم من خلال البحث عرض تلك النتائج بناءاً على البحث النظرى والتجربة العملية ومنهجية العمل داخل نموذج "التصميم للجميع" والذى قامت بالتعرض له للاشخاص المبصرين والغير مبصرين على حد سواء داخل أحد البوسترات او

المطبوعات اليومية التى يمكن للنوعين من الاشخاص التعامل معها. وقدم البحث طريقة العمل وتفاصيل بعض الخطوات التى اوصت بها بعض مواصفات الايزو للتعامل مع المكفوفين كأسلوب الحصول على نتائج البحث بعد تحليل الاستبيان الذى تم على بعض المكفوفين فى مراحل عمرية مختلفه لما له من تأثير على قدراتهم الاستيعابية والمهارية المتنوعه والذى لوحظ تأثيره فيما بعد على قراءة محتوي النصوص والصورة وتم إدارجة فى مستخلص النتائج والتوصيات

الكلمات المفتاحية:

الطباعة الرقمية، التصميم للجميع، التصميم الجمالى، ارجنومية، التعليم

1. Introduction:

Swell (embossing) or microcapsule paper is arguably the most popular method for producing tactile diagrams and text for the visually impaired. This method presents the traditional braille printing method, even if it involves the use of a digital machine capable of transforming the information on the computer into the braille alphabet through the microcapsules inside the leaves of paper. However, developers have produced a new form of production involving swelling on the paper with inks using the digital printing method with a wide range of ink adhesion, durability, and resistance to rubbing and touching. This form of embossing presents the so-called “design for all” approach. Thus, we currently have two methods of producing tactile information in braille.

The author has found that the acceptance has become a major source of motivation for improved human factors in production and designing, while the major decisions of the profitability of one of two production systems had the base to start this paper research.

2. The importance of the research

It is important to better understand the issues faced by the visually impaired when reading using the braille system and the attendant ergonomics of both traditional embossing production and the new digital printing technology embossing the use of inks.

3. The aim of the research are

1. To compare the performances among a sample of individuals in recognizing the text when presented with traditional embossing and digital printing.
2. To identify the differences in performance across the selected visually impaired individuals.
3. To generate recommendations for the most suitable method for achieving the optimal human ergonomics.

4. Research methodology

The study is based on experimental analytical research aimed at describing and applying digital printing and traditional embossing methods for braille before analyzing the human factors and the ergonomics in relation to both methods.

5. Operational definitions

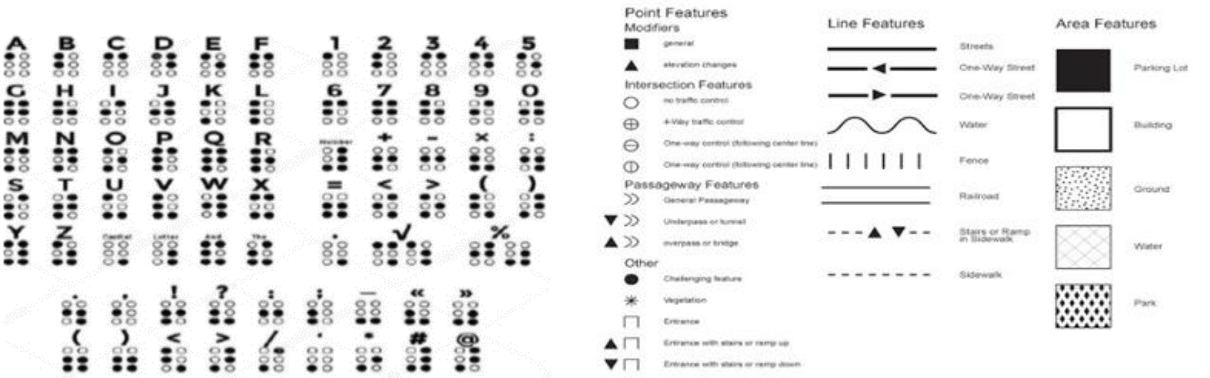
Visually Impaired: A person is defined as visually impaired if they have no vision, greatly reduced vision, or partial vision but can read using a tactile braille system without the assistance of a sighted person or assistive technology.

Practical problems: Practical problems can be defined as difficulties or problems faced by the visually impaired in terms of tactile reading.

Expert: An expert is defined as a visually impaired trainer or teacher working with both visually impaired and normal-sighted individuals.

6. Braille

The braille writing system is made up of embossed dots within a cell composed of a 3 x 2 configuration wherein three dots are arranged vertically and two horizontally. Each dot in a braille cell is numbered based on its position, from 1 for the top-left dot to 6 for the lower-right dot. This six-dot braille system is the most widespread and popular system in many countries, while a number of countries have also introduced the eight-dot braille system for certain functions. The embossed single dots or a combination of dots in a braille cell represents a letter, a word, a number, or another character as determined by its rule of use in any particular language. The braille system is extremely limited and the introduction of new and complicated symbols can only be done through the contraction and combination of the existing braille cells (Zarif, 2014, Figure 1). Visually impaired individuals learn by touching and feeling the system of dots (S. Uma, 2018).



(a) **(b)**

Figure 1: a) Braille alphabet (S. Uma, 2018), b) braille symbols

6.1 Tactile communication

Tactile communication relates to the sensation perceived via the sense of touch. Blind and visually impaired individuals rely heavily on touch feedback, while those who are both blind and deaf are totally dependent on their sense of touch. Tactile technology can enhance the capabilities of the visually impaired through facilitating the navigation.

6.1.1 Braille parameters should consider

1. Tactile recognition of prints.
2. Adequate height and size.
3. The number of selected raised objects, their formation, and the selected texture.
4. The width of the tactile lines (thinner lines can be used for defining the edges of less important but still significant features).
5. The number of lines (should be kept to a minimum).
6. The fact that the text written in braille occupies more space should be considered. It is suitable to use larger but not too large braille fonts for easier reading. The regulations define

the specific dimensions of the braille cells and the individual dots (German Institute for Standardization, 2007, ISO 17351, 2013)

6.1.2 ISO Standards

- ISO 9241-11: describes in detail how users should interact with a product to indicate its usability. Briefly, the recommended technique is to record users while they interact with the product.
- ISO 17531- 2013: describes in detail the braille on packaging for medicinal products, which includes braille cell specification and dot height, burst through, labeling, and the determination of the braille legibility.

6.2 Relationship between ergonomics and language

Ergonomics is the approach that applies scientific data and principles to the design of equipment, products, tasks, devices, facilities, environments, and systems to meet the needs of human productivity, comfort, safety, and health (Board of Certification in Professional Ergonomics (BCPE), 2002). Elsewhere, the Human Factors and Ergonomics Society (HFES) define ergonomics (or human factors) as the scientific discipline concerned with the understanding of the interactions between humans and other elements of a system, and as the profession that applies theory, principles, data, and other aspects to design to optimize human well-being and overall system performance (HFES).

6.2.1 The goals of the work on human factors

1. Improving the productivity and efficiency of performance. With any reduction in time and any increase in performance accuracy, manpower requirements, and thereby costs, are reduced.
2. Reducing personnel recruitment and training requirements, minimizing the selection criteria you must impose, and the training effort required for development of adequate personnel which can be directly translated into cost saving.
3. Improving the safety of a product. Safety has huge indirect payoffs in terms of reduced legal liabilities. The cost of the exposure to personal liability cases involving design negligence has become a real issue for most major industrial organizations.
4. Promoting consumer acceptance. Acceptance has become a major source of motivation for improving human-related design aspects, with application design an integral part of the system itself. Under these conditions, the human aspects of the design become an integral part of its competitive advantage (R. Paw 1978).

The reality is that the professionals dealing with the human factors are generally good at scientifically measuring the effects of our work. The issue is that our metrics are often very different to the factors that the customers and the decision makers are concerned with. To be successful, we need to translate our metrics into their metrics. Table 1 shows the attendant value proposition.

Table 1. The value proposition (Endsley, 2012)

The Value Proposition (Endsley 2012)	
Human Performance Metrics	**System Performance Metrics**
• Task Time	• Manning Levels
• Error Rates	• Mission Success Rates
• Workload	• Production Rates
• Situation Awareness	• Downtime Costs
• Physiological Measures	• Cost Savings (accident costs, medical costs, training time . etc.)
• Reach/Fit	• Product Sales
• Usability	
Our Metrics →	**Their Metrics**

7. Ergonosemiotics

Every language has its own conventional symbols. A good designer considers the different cultural and linguistic symbols of the target country when creating a product's instructions. In writing instruction by ergonosemiotics rules the braille alphabets for the blinds considered. In general, ergonomic semiotics is a suggested name for this approach, which is a combination of linguistics, semiotics, and ergonomics (Dastenaee, 2019)

7.1 Methodological approach: Knowledge of the "use" context as a design reference

Starting with the "design for all" approach, of particular interest are the content and intervention philosophy of the International Classification of Functioning, Disability and Health (ICF) and the international regulations provided by the ISO, pursuant to standard I20282/2006, "Ease of operation of everyday products (daily use) – Part 1: Design requirements for context of use and user characteristics," as well as the ISO/IEC Guide 71/ 2001, "Guidelines for standard developers to address the needs of older persons and persons with disabilities."

The ICF classification describes the individual health conditions according to three different perspectives or dimensions:

1) Body functions and structures: this refers to the actual anatomy and physiology/psychology of the human body.

2) Activity and participation: this refers to the individual's functional status, including in terms of communication, mobility, interpersonal interactions, self-care, learning and applying knowledge.

3) Contextual factors: these include any environmental factors that are not necessarily within the individual's control, such as family, work, government agencies, laws, and cultural beliefs, as well as personal factors such as race, gender, age, educational level, and coping style. Personal factors are not specifically coded in the ICF due to the wide variability among cultures. However, they are included in the framework since, while they may be independent of the health condition, they may have an influence on how an individual function.

These three dimensions allow for defining the functional levels, which are designed according to the contextual factors, including the environmental and personal factors.

From a methodological point of view, a number of reference points can be pinpointed for the development of an integrated approach to the Ergonomics - design for all concept that may allow for the integration of braille into the printing technology specified for the use of sighted individuals (Tosi, 2012). In short, an effective approach would involve using the same printed products, such as books or packaging products, for both sighted and visually impaired individuals. This point relates to the contribution that the methodological setup of ergonomics can make to the design for all approach. Both the cognitive tools and the methods of assessing the ergonomic quality of the products could, in fact, represent the practical design and process innovation instruments that are capable of implementing the numerous proposals and content of the design for all approach. While this approach has been implemented numerous times to produce printed braille designs for both sighted and visually impaired individuals, the technology used to produce the printed materials in braille has tended to relate to the traditional form of embossing (Figure 2).

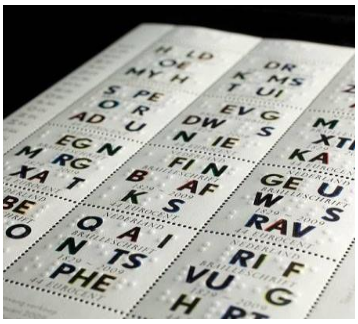


Figure 2: Example of the design for all approach

8. Difference between traditional embossing and digital printing

Both methods present a form of assistive technology. A braille embosser works by embedding raised dots onto a piece of paper within a computer file translated into braille language (techopedia.com, 2019). Meanwhile, digital printing technology prints the dots onto paper using ink, with the thickness of the ink dots creating the structure of the raised braille characters.

8.1 Digital printing

8.1.1 The b.my.jet laser printer

The European Union’s research and innovation program, Horizon 2018, funded the development of a digital printer through a powered project involving British and Hungarian engineers. The resulting “b.my.jet” printer produces digitally printed tactile matter in the form of braille, as well as figures, maps, and graphics. This allows for instant access to a wide range of braille material at a significantly reduced cost compared to the current embossing technology. The end goal is to create a desktop printer that will also include scanning and “copy to braille” capabilities. This digital printing process differs from the traditional embossing methods, which are analog-based, inflexible, and not “on-demand” for users. The new printer will be developed as a desktop device with operating costs comparable to those of a laser printer. This advance in technology will broaden the scope of printed materials in general and, while the primary aim is to empower blind and partially sighted users, it could have further applications in areas such as educational therapy (BrailleJet report, 2018, Figure 3a).

8.1.2 Azon inkjet printers

Azon printers used in conjunction with the Azon RIP software can print up to five layers in the inline mode. Here, through changing the resolution and the number of nozzles, and through using the fading technique, individuals can create raised prints of up to 2 mm, which means they can print regulation-standard braille in ink (Micro Piezo Head, 2019). One of the more effective accessories used with such technology is the Rotax adapter that allows for printing on a vast range of cylindrical objects with diameters ranging from 41 to 127 mm and heights of up to 279 mm. Printing on cylindrical and cone objects such as glasses, cups, candles, tubes, cans, tanks, or vases allows for creating, for example, awards, tactile signage, and a wide variety of packaging (azonprinter.com, n.d, Figure 3b).

8.1.3 Roland Versa UV LEF-12i UV printer

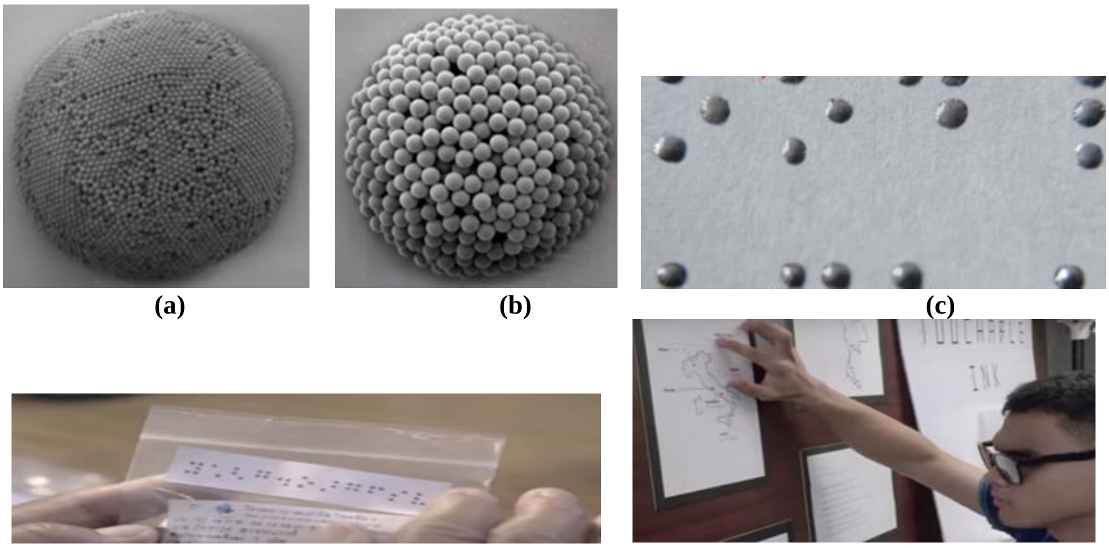
UV printing technologies can be used to print onto virtually any object. In addition to the breadth of applications made possible with CMYK UV ECO inks, the gloss ink unlocks even more possibilities. This ink can be printed in layers to achieve tactile effects and 3D textures, making it an ideal solution for high-volume braille applications. The machines range in size from the benchtop Versa UV LEF-12i UV printer to a wide-format S-Series, and can be used to print braille directly onto signage or packaging (Rolanddga.com, 2020)

(a) **(b)**

Figure 3: a) Braille Jet printer (source: EU research program), b) Azon Razor inkjet printer (source: Azon)

8.1.4 Samsung collaboration: "Touchable ink innovation"

Samsung has developed a type of ink that allows any home or desktop laser printer to be transformed into a braille printer that produces a braille font through mixing embossing powder with ink, which, when heated, becomes raised much like embossed characters. The "touchable ink" development project was a collaboration involving Samsung, the Thailand Association of the Blind, and a chemistry professor at Thammasat University. Users can simply replace their ink cartridge with the touchable ink cartridge before changing the selected document to a braille font type, printing it out and then heating it with a general heating device. Testing has been carried out with visually impaired participants from the Thailand Association of the Blind. Here, more than 90% stated that the resulting text was readable, smooth, and comfortable (Samsung, 2020, Figure 4).



(a) (b) (c)

(d) (e)

Figure 4: a) The ink before any other solutions are added, b) the ink created through mixing embossing powder

with ink, **c)** the printing paper becomes braille paper after printing using the touchable ink, **d)** test 1 from the Thailand Association of the Blind using an aspirin printed product, **e)** test 2 from the Thailand Association of the Blind using tactile mapping.

9. The experimental study and the ergonomics questionnaire

9.1 Protocol

This study focuses on analyzing the difficulty and the level of comfort involved in traditional embossing and digital printing prototypes in relation to reading braille text. Here, the paper investigated and evaluated the physical characteristics of the braille code printed on the documents and packaging, largely in terms of the height of the braille characters that allow for tactile reading. the author adopted the use of interviews, in which the aim of the study was introduced before the interviewees were asked for their opinions on different aspects of the study that were deemed as important. A survey was also carried out involving four visually impaired users.

9.2 Experimental

9.2.1 First experiment: Traditional braille production (paper embossing)

The first part of the practical traditional embossing was carried out using the following steps:

1. Preparing the design for both sighted and visually impaired people (design for all) including text and images related to the same point of view of the main subject using Microsoft Word.
2. Two tactile training diagrams of varying complexity were chosen from real photos and then applied as vector images.
3. Commencing the print design for the sighted people using a Canon image PRESS C10000VP/C8000VP machine.
4. Using the following applied tools and workflow to produce the final traditional embossed braille tactile prototype:

- using the INDEX Braille Box V5 machine for traditional embossing

- opening the Duxbury Braille Translator program, then opening the saved word.doc and importing the file
- choosing the language
- from the dropdown menu, selecting Global → Embosser setup, Document → Page Numbering
- selecting File → Translate, Layout menu → Picture → Add
- selecting File → Emboss

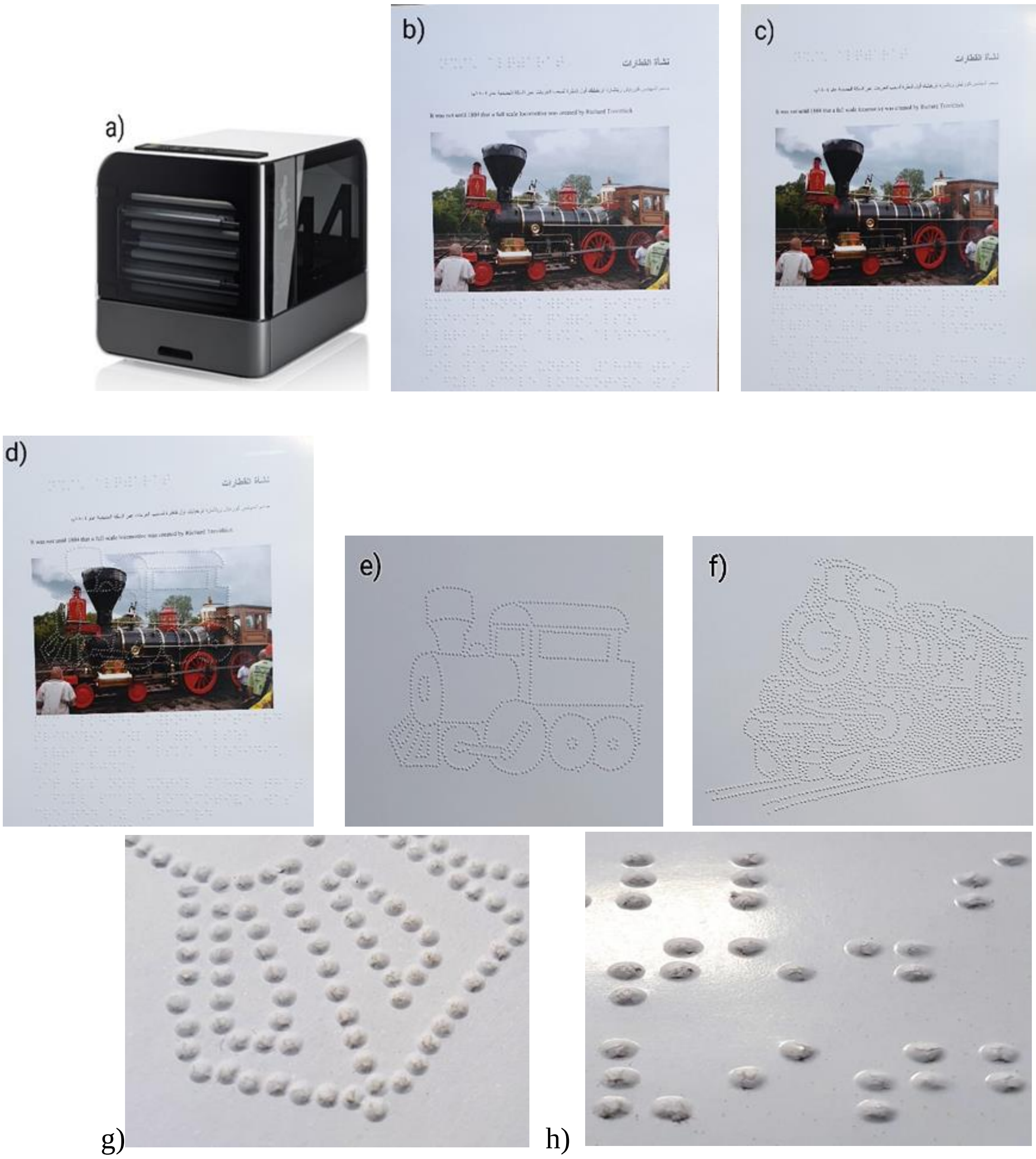


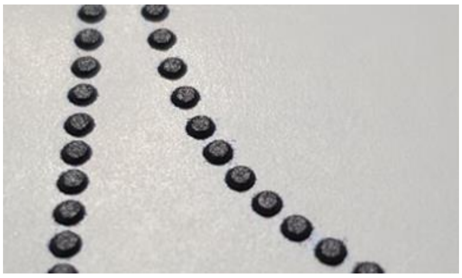
Figure (5): a) INDEX Braille Box V5 machine, **b)** the design for all after printing on the Canon image PRESS C10000VP/C8000VP for sighted people merged with the second production process for the visually impaired people embossed on the INDEX Braille Box V5, including text only for the visually impaired people on Bristol matte uncoated paper with a weight of 150 gm, **c)** the same process using Couche gloss-coated paper with a weight of 150 gm, **d)** NUMBER (C) in addition of adding the embossed train picture for the visually impaired people above the printed train picture for the normal people, **e)** separated embossing of the traditional braille for the train picture, **f)** another trial of a complicated train with a lot of details after translated into traditional braille embossed dots, **g)** Tactile dots result zoom in shows dots explosions causes dots pin heads in Bristol matte uncoated paper, **h)** Tactile dots result zoom in shows dots explosions causes dots pin heads in Couche gloss- coated paper and the image shows that explosions in Couche gloss- coated paper were much more than the other dots explosions in Bristol matte uncoated paper

9.2.2 Second experiment: Digital printing braille production (ink embossing)

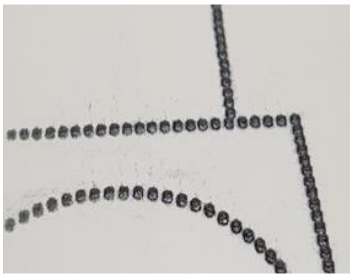
The second part of the practical test involved digital printing using inks for braille tactile design, the following steps:

1. With the previous prepared design for all. I started with printing the image for sighted people on the same digital printing machine used in the first experiment.
2. Printing the design for sighted people on the Canon image PRESS C10000VP/C8000VP machine.
3. Using the following applied tools and workflow to produce the final digital printing braille tactile prototype:

- Using a Roland versa UV LEF 300 printer for inkjet embossing.
- By using the Versa Works program and RIP interface, PDF file processing was carried out to the machine/
- Using an ink calculator to estimate the amount of ink needed for the job, and the appropriate number of layers were added as follows:
  - for dots with a height of 0.3 mm, three ink layers were added.
  - for dots with a height of 0.6 mm, six ink layers were added.
  - for dots with a height of 1.2 mm, 12 ink layers were added.



a)



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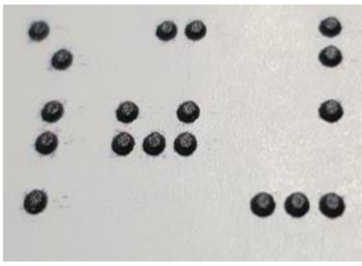

c)

d)

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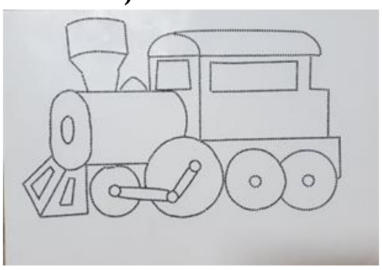

f)


g)


h)

Figure (6): a) The ink dots result of the train with height almost 1.2 mm (without dot gain), **b)** ink dots result even the space is too small between dots and the dots itself is too small for a specific details if needed, still it shows a precise and very accurate dots without dot gain, the inks height 0.5 mm, **c)** Tactile braille Alphabet embossing with inks with height almost 1.2 mm, **d)** Tactile braille Alphabet embossing with inks with height almost 0.3 mm, **e)** Roland versa UV LEF 300 machine for ink jet embossing, **f)** The train braille illustrations printed by digital printing method, **g)** The design for all after print on the Canon image PRESS C10000VP/C8000VP for normal sighted people merged with the second production process for the visually impaired individuals embossed on the Roland versa UV LEF 300 include text only for the visually impaired individuals on Bristol matte uncoated paper weight of 150 gm with a dots height 0.3 mm, **h)** The design for all after print on the Canon image PRESS C10000VP/C8000VP for normal sighted people merged with the second production process for the visually impaired individuals embossed on the Roland versa UV LEF 300 include text only for the visually impaired individuals on Couche gloss-coated paper weight of 150 gm with a dots height 1.2 mm

10. The questionnaire interviews

The interviews were divided into several sections with each related to a specific aspect. At each stage, the interviews were free to express any ideas regarding the topic in question. The questions included the following:

1. A few personal questions

- Name, age, job status (if they have), vision status, age at which they became blind.

Answer: There were three men and one girl, who were aged 13, 18, 23, and 42. Three were born blind and one lost his sight a year and a half after birth. The vision status for all is “totally visually impaired.”

2. Braille

- How familiar are you with braille?

Answer: All of them have the ability to read using braille from kindergarten age (i.e., they had 8, 13, 18, and 37 years' experience of reading using braille, respectively). Three were still in education and one is employed.

- What are the advantages and disadvantages of using braille and what are the attendant practical problems?

Answer: They all consider being able to use braille as an achievement, with the main advantage being that it allows them to connect with sciences, education, culture and other areas. Unfortunately, it does not encompass everything and they still hope that braille could help enhance their imagination or their cognitive awareness, despite the opinions of the experts. However, there is a practical problem in that children often find that traditional braille feels like "pins" and is neither smooth nor comfortable.

- Do you use braille for reading books, packaging, banking buttons, etc.?

Answer: The only braille content here in Egypt is in books and the ATM buttons, with no packaged goods including braille such that visually impaired people can differentiate between, for example, medicines which they make a special way by butting a sign to know the medicine packaged one from each other. There are also no roads signs written in braille.

- What kind of braille-based devices do you use, if any?

Answer: Three of the participants do not have any devices for reading braille, only reading books and maps if they find them in the education labs. Meanwhile, one participant has an electronic device called Human ware Braille Note.

3. Physical state of holding braille prints (books, newspapers, currency, packaging, etc.).

Answer: All the participants preferred to place the braille books or papers on a desk or table while reading them, which makes the process more convenient and comfortable.

- How do you hold the prints when you read them?

Answer: All of the participants place the prints over their legs while reading them, which means they require more time to read them due to the instability.

- How do you prefer to hold the print (with the thumbs of both hands or with one of your pointing fingers)?

Answer: All the participants read with both of their hands using two or three fingers.

What are the main problems with reading prints?

1. Please score the following aspects of reading traditional braille embossed texts and digital braille printing texts from 1 to 4 (1 means you prefer traditional braille embossing tactile, 3 means you prefer braille digital printing tactile, 2 means they are equal, 4 means you are still not comfortable with either and that they require modifications).

If you choose number 4, please declare the modifications you suggest.

If you choose number 2, please clarify why?

Answer: Three of the participants chose number 3, while the fourth chose number 2, stating that he had found no difference between the two samples, having used braille for 37 years, which means he has no trouble with reading.

2. Please score the following aspects of illustrations produced with traditional embossing and digital printing from 1 to 4 (1 means you prefer the traditional embossing, 3 means you prefer the digital printing, 2 means they are equal, 4 means that you are still not comfortable with either and that they require modifications).

If you choose number 4, please declare the modifications you suggest.

If you choose number 2, please clarify why?

Answer: All four participants chose number 3 here, finding the digital printing to be superior to previous illustration techniques (i.e., traditional embossing).

3. Please score the following aspects of traditional embossing and digital printing from 1 to 4:

• speed
• accuracy
• easy to learn or to read
• height of the dots.

Here, 1 means excellent, 2 very good, 3 good, and 4 poor.

Speed: Three of the participants chose 1 here for the digital printing, meaning the speed of reading the digital printing was excellent, while they found the traditional sample to be slower to read. The fourth user found the traditional sample faster to read as each dot had a pin that annoyed him and he thus read faster.

Accuracy: Four of the participants chose 1 for both, while they did prefer the accuracy of the digital printing sample, especially with the illustrations. The users also expressed their desire to use digital printing for maps and detailed illustrations due to the higher accuracy.

Easy to learn or to read: Three of the participants chose 1 for the digital printing sample, which they found much easier as well as more readable, smooth, and comfortable than the traditional one, while the fourth found no difference between the two.

Height of the dots: Three of the users found both samples to be excellent, while the heights did vary with the digital printing sample. They found the height of 0.3 mm to be readable even though this was lower than what they were used to. In addition, the diameter of the ink dots appeared to be similar to that of the traditional braille method, without any notable gain.

11. Human Factors: Usability data at the experiment by the impaired individuals

Objective (performance) data analysis, as recommended in ISO 9241-11 and ISO 17531-2013 using the following aspects:

1. Visually impaired users rely heavily on touch feedback, while individuals who are both visually impaired and deaf are totally dependent on their sense of touch. None of our users were deaf, while they do use a hearing application for general assistance; however, this does not apply to everything, meaning braille remains the most important means of recognizing things for them. Thus, tactile technology could enhance the capabilities of the visually impaired by improving their navigation, ensuring it is both intuitive and discrete.
2. The author observed any errors of use and users notes. Here, it was found that the four braille users were unable to understand the detailed illustrations printed using traditional braille, while the digitally printed illustrations offered clearer, more detailed explanations for usage.
3. The author observed the users' performance during the reading and found that most of the users preferred to read the digitally printed text and illustrations and did not find the new method of production to be weak. They required no assistance with the digital braille printing text, even though the height of the dots was low, finding its usage to be very good with no need for additional tips or any reference to the instructions for use.

- The digitally printed braille, including the swell of the dots of the script, that was very comfortable to the users, while they found each dot of the traditional sample with a pin head that makes them feel less comfortable. Most of the participants thus call for the use of digital printing with inks.
- The younger participant was 13 years of age and always read children's magazines with text and illustrations suitable for that age group. Here, she suggested that digital printing must be used for these materials and she called for that purpose more than the other users.

4. The author did not interfere with the participants' independent and natural use of both forms of braille; however, they all had a problem with the traditional method in terms of understanding any additional details.
5. The author evaluated the physical characteristics of the braille code printed on the posters in terms of the height of the system that allows for tactile reading. It was verified that the height values of the digital printing were varied (0.3–1.2 mm), while with the traditional printing, the height was consistently about 1.4 mm without any ability to produce another height. The author measured the ease of reading with the different heights of the two methods. The heights were found to provide comfortable reading with the digital printing sample (even at 0.3 mm and still can recognize the texts without no need to try reading with that low height several times), with the users easily understanding the text. In fact, the younger participant found the circular dots of the digital printing to be extremely comfortable and that it felt more familiar, while she liked the medium-height dots ("as she said: not too high or too low").
6. The speed of reading completion was also measured, which was high for both samples, even with the lower heights of the digital samples. However, the speed with the illustrations in the case of the traditional sample was not so high and the users needed help. The number of attempts to understand the illustrations was also counted. Here, the traditional sample had to be read two or three times, while it was far quicker with the digital printing sample and little assistance was required.
7. It was found that the users preferred to read from the Couche gloss-coated paper than from the Bristol matte uncoated paper, for both forms of production.
8. Half of the users felt that the number of ink dots in the digitally printed illustrations could be reduced without the illustrations becoming more difficult to understand.
9. One of the users have an opinion that should be considered, is that some of the visually impaired people have hand touch and fingers sensation deficiency or low touch sensation and they need the highest dots ever, the author has found that the only way to handle that special case by using customized inks levels which can be variable in the digital printing braille, it can be made till height 2 mm while we cannot do the same with traditional braille production which its heights are fixed.

12. Discussion

1. Braille producers are looking for diversify in their business and offer a wider range of products and services. This cannot be achieved using the traditional embossing braille, while it could be achieved using digital embossing printing braille.
2. While we now have various technologies related to digital braille printing, none have been scientifically studied or tested to prove their efficiency. However, the success of digital braille

printing and its acceptance among the visually impaired have been very high throughout the world.

3. Digital braille printing samples have proven to be more ergonomically clear, smooth, and soft in comparison with traditional braille production.
4. Corners and sides, detailed illustrations not much easier for impaired people to find, unless they are used to use the print for many times, in spite of that digital printing dots ergonomics made a specific change on the visually impaired people point of view about the ability and ease of recognition of the objects.
5. In terms of morphology, specific information and detailed diagrams such as models of plants, they cannot be produced using traditional braille embossing, since each dot will cause a "paper explosion" where pin heads will appear. However, this would be possible using digital printing inks. By customizing the diameter of the ink film and the height of the tactile system's characters, digital printing can be used to present, for example, the detailed and delicate parts of plants such as leaves or maps …etc., which will offer a different point of view of the new designs among the visually impaired. In addition, when presenting the specific properties and features of illustrated objects, too much information could confuse and mislead visually impaired people, due to excessive amount of information to be printed and the reader can't recognize the tactile image. In brief, every object must be printed with an appropriate scale to make it easier to print and read.
6. Illustrated objects with specific details can be formed using different printing inks. Here, we could simulate grained objects (e.g. sand), rough objects (e.g. fruits), and smooth objects (e.g. leaves of grass).
7. Changing the height of the dots to be higher or lower, the number of dots, the distance between them, or even the diameter of the dots when printing illustrations allows for greater flexibility than traditional embossing, which will improve the designs for visually impaired people and will present a new concept for the "design for all" approach.
8. Using digital printing with inks means different colors, transparent inks or UV varnish can be used. Here, while severely visually impaired people will not see the colors, they will help the designers to create aesthetic designs suitable for all without annoying the normal sighted people in their colors and feelings of the papers. For example, in our experiment, there were train on a poster for normal-sighted people and one of the trials involved placing the trains' one above the other, which proved difficult using the traditional braille method. In short, the paper explosions destroyed the image of the train for the normal-sighted people, while it could be printed digitally for example with transparent inks above the train of the normal sighted people and still they can see their train clearly.
9. Digital printing using Bristol matte uncoated paper consumes more ink than when using Couche gloss-coated paper due to the adsorption of the paper fibers to the ink droplets. In fact, all the visually impaired people preferred using the Couche gloss- coated paper. Thus, this type of paper was deemed to be the best with its low inks consumption and preferable by the visually impaired people.
10. The instability of the prints when reading them presented a practical problem for the visually impaired people, which was the case with both methods. Here, it was ascertained that the prints must be placed on a hard surface such as a desk.

13. Conclusion

Books as well as places such as laboratories can be made more accessible for visually impaired people through modifications involving the integration of digital printing assistive technologies, which could provide tactile output ergonomics for the facilitation of practical observation. This will help visually impaired people interested in literature, geography, or the sciences to pursue their goal of achieving higher education and contributing to the development of science and technology. Meanwhile, in the areas of packaging, learning, advertising campaigns, road mapping, and detailed diagrams and signs, etc., digital printing embossing will be useful for the creation of unique products under the “design for all” approach aimed at both normal-sighted and visually impaired people. Here, if the integration of digital printing proves to be too expensive in certain cases, the author suggests merging the two methods of production, while the texts can be produced in the traditional way and the illustrations produced should be using digital printing. Overall, tactile display technology incorporating digital printing is a promising area for future products that will improve the lives of many people.

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