THE INTELLIGIBILITY OF TACTILE GRAPHICS AS PERCEIVED BY BLIND STUDENTS

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Abstrak

Gambar rajah timbul ialah komponen yang penting dalam pendidikan kanak-kanak cacat penglihatan. Untuk menguji keberkesanannya, peserta tinjauan telah memberipersepsi mereka tentang sejauh manakah gambar rajah timbul yang digunakan di sekolah mengakuri spesifikasi yang disyorkan oleh para penyelidik serta badan-badan profesional yang mengeluarkan gambar rajah timbul. Data yang dikumpul dicerakinkan dan dihuraikan demi menentukan aspek reka bentuk gambar rajah timbul yang perlu diberi lebih perhatian dalam usaha meningkatkan mutunya. Dimensi reka bentuk gambar rajah timbul yang mendapat skor melebihi markat min ialah susun letak maklumat, kejelasan simbol timbul, dan keringkasan gambar rajah. Dimensi yang mendapat skor kurang daripada min ialah kesesuaian simbol, dan arahan kepada pengguna. Sebanyak 28 spesifikasi reka bentuk gambar rajah timbul disenaraikan mengikut urutan skor yang diberikan oleh responden soal selidik terhadap sejauh manakah setiap satu spesifikasi itu telah diakuri dengan baik. Hasil dapatan kajian ini dapat membantu guru dan pembuat gambar rajah timbul mengenal pasti aspek reka bentuk yang perlu diberi lebih perhatian supaya ianya sesuai dan dapat digunakan dengan berkesan oleh pelajar cacat penglihatan.

INTRODUCTION

Tactile graphics are maps and diagrams produced on a two-dimensional surface in embossed lines, shapes and textured fields so as to be accessible to the sense of touch (Weidel & Groves, 1969). They are an important part in the education of blind children. Not only in sighted textbooks, nowadays, braille textbooks contain an ever-increasing number of graphics (Connell, 1995). Hence transcribers or makers of tactile graphics should make them as easily understood as possible for their target users.

Various factors contributing to the intelligibility of tactile graphics have been published in previous research and professional guidelines (Aldrich & Sheppard, 2002; American Printing House for the Blind, 1997; de Boer, 1999; Wiedel & Groves, 1969).

The Five Dimensions of Intelligibility

The five factors contributing to intelligibility of tactile graphics are:

1. Formatting of information- Research findings (e.g. Everett & Gilbert, 1992) agree that it is more difficult for the blind to construct a tactually oriented imagery of space. It is therefore important that information presented in tactile graphics should be structured carefully to aid reading. Graphics transcribed from sighted originals need deliberate restructuring to accommodate blind readers. The specifications contributing to this dimension are:
    a. Location of graphic- Graphics should be placed nearest to the corresponding discussion in the text. This is supposed to ease locating and referencing of information (Shodor Education Foundation, 1996).
    b. Rescaling of graphic- When there is a lot of information within a graphic the transcriber must consider rescaling the graphic to a larger size in order to alleviate congestion of its elements (Weidel & Groves, 1969).
    c. Orientation of graphic- Frank de Boer (1999) pointed out that the difference between horizontal and vertical page orientation should be made more obvious by putting the title above the diagrams and adding the North arrow in maps.
    d. Sequence of instructional information- The American Printing House for the Blind or APH (1997) suggests that all titles, keys and legends be placed before the graphic instead of after as in visual graphics.
    e. Restructuring of graphic into parts or sequence- Where much information is to be presented, it is better to break it up into several diagrams rather than cramming it all up in one (Horsfall & Vanston, 1981).
    f. Alignment of text and labels- All text labels must be placed in the same direction within a graphic, and not squeezed into small spaces or rotated at various angles (de Boer, 1999).

2. Tactual clarity of features- The fingertips, however trained, are not capable of detecting outlined shapes and textures as easily as the visual mode (Horsfall & Vanston, 1981). Should there be a misperception or occlusion of some significant information, the conceptualized whole could become distorted. To avoid confusion, tactile graphics should be clear and complete. The specifications contributing to this dimension are:
    a. Clarity of lines- Berla and Butterfield (1977) identified two major problems in reading tactile graphics: difficulty in tracing lines and locating distinctive features of outlined shapes. They suggest that all lines must be raised with a wider border.

b. Intersection of lines- Berla and Butterfield (1977) observed that broader lines can alleviate problems when tracing along the top surface of a line, while de Boer (1999) recommended that line intersections be emphasized by nodes.
c. Shape symbols- The American Printing House for the Blind (APH) (1997) suggests that all shape symbols must be more than half an inch in diameter.
d. Texture-filled shapes - According to Aldrich and Sheppard (2002), shapes should be filled with textures rather than left empty within outlines because it can be difficult for blind users to know whether they are feeling inside or outside a given shape.
e. Spacing between symbols- Inferring from blind children's braille reading abilities, the spacing between symbols are recommended to be at least the distance between dots on a Braille cell (Andrews, 1985).
f. Discrimination of textures- The 8 area patterns supplied in APH's Tactile Graphics Starter Kit (http://www.rit.edu/~easi/easisem/graphaph.html) can be used as reference for textures that can be easily recognized by blind readers.
g. Relief or multiple height treatment- Shimizu, Saida, and Shimura (1993) have shown that relief presentation was superior to the line-drawing presentation in accuracy of recognition and mean recognition times.

3. Appropriateness of tactile symbols- The reader of a tactile graphic has to be in tune with the maker's perception of what each symbol in the graphic represents before he or she can effectively appreciate the concept presented. Thus, special emphasis must be given to the way symbols represent the concepts and information to be conveyed to the blind reader. Design and choice of graphical symbols must match the blind child's previous experience of tactile graphics and not just the transcriber's visual perception of it. The specifications are:
   a. Discrimination of positive from negative spaces- Kennedy and Domander (1984) found that foreground/background reversal of tactile graphics causes considerable recognition problems among blind children. Shape symbols must either be textured or distinctly raised from the flat base and not to be confused with negative spaces.
   b. Less prominent use of lead lines- Aldrich and Sheppard (2002) advise that lead lines are symbolic references to text and should therefore be used only when absolutely necessary, and if so, they must be less prominent than line symbols.
   c. Arrows only as indicator of direction- APH (1997) states that arrows are only used to show direction of movement and not to be confused as lead lines.
   d. Consistency of symbol representation- The symbols used within a graphic must consistently refer to the same feature.
   e. Braille dots should not be used as texture- Braille dots are not to be used as textures because The Shodor Educational Foundation Inc. (1996) states that young readers have difficulty distinguishing them from actual text meant for reading.

f. Logical consideration in selecting symbols- The choice of symbol designs mainly lies on logical considerations. For example, it would be misleading to choose a heavily textured surface to symbolize water bodies, or use point symbols to represent large objects.

4. Simplicity of design- According to Millar (1976) and Herman, Chapman and Roth (1983), tactual memory representations decay more rapidly with time and can be easily interfered by new stimulus encountered during movement. Therefore saturation of information within a tactile graphic can jeopardize reading and understanding. Best (1995) says that it is advisable to reduce the amount of information to be presented in tactile form. Clutter will confuse and frustrate the reader.
    a. Rescaling of parts- Ungar et al. (1999) reported that for blind subjects, distances between spatial elements are treated as functional rather than Euclidean. Based on this finding, it is correct when Hinton (1991) advises that in a teaching diagram, it is feasible to distort the original picture in various ways to emphasize a point for teaching or interpret a structure for a blind reader. Shapes within the graphic can be enlarged or distorted to accommodate information.
    b. Simplify three-dimensional drawings- Perspective rendering and three-dimensional drawings are not easily understood by a congenitally blind reader unaccustomed to the conventions of visual appearances. APH (1997) states that these figures should be replaced with cross-sections or front, side or top views.
    c. Editing extraneous information- Both APH (1997) and Aldrich and Sheppard (2002) emphasized the need to weed out any information that does not pertain directly to the subject represented. The maker has to extract only relevant information and leave out all extraneous details and decorative elements.
    d. Controlled use of textures- Too much use of textures can be distracting. APH (1997) recommends that they be used sparingly only to add information. Rough textures can give rise to tactual fatigue and desensitization, which can cloud the legibility of tactile graphics.
    e. Controlled use of text- APH (1997) encourages that textual information that clutters the graphic should be abbreviated or replaced by a character, which is explained in the legend.

5. Availability of instruction and reading cues- To eliminate or minimize ambiguity, producers of tactile graphics must add suitable captions or accompanying text to help the readers (Hinton & Ayres, 1987). The blind reader always relies on transcriber's notes and other reading cues, such as the title, captions, keys and legends to aid reading of the graphic.
    a. Transcriber's notes- Transcribers can start by giving an overview of the graphic. Where modifications have been made in the structuring of information, these notes can enlighten the reader (APH, 1997).
    b. Starting points- Weidel and Groves (1969) suggests starting points to give a sense

of orientation and create a focal point to which the reader can always return in case he or she gets lost in the reading.

c. Extra labelling- APH (1997) recommends that features not labelled in the sighted original, but deemed important for the blind reader to know, should be given labels or textual clarification.
d. Keys and legends- Keys and legends are invaluable sources of instruction. Understandably, all symbols and text abbreviations not described within the graphic need to be clarified in them.
e. Replacing graphic with textual description- The Shodor Educational Foundation, Inc. (1996) states that pictures that can be more effectively described by words should not be transcribed. In fact, the first guideline given by APH (1997) is to decide if a tactile graphic needs to be made at all. The information contained may not be relevant at all to the topic discussed in the text. When this decision is made, the transcriber should supply a note regarding the omission.

Despite the availability of guidelines and handbooks on making tactile graphics as intelligible as possible for blind readers, Aldrich and Sheppard (2002) report that educational programs for the blind had not given adequate attention to tactile graphics. The researchers found that many teachers of blind children in SM Pendidikan Khas Setapak (Setapak Special Education Secondary School for the visually impaired, SMPKS) agreed that this comment is equally, if not more so, true in the Malaysian context. But what do the target users of tactile graphics, namely the blind students themselves, actually think about the design of tactile graphics for their use at school? In which aspects do the tactile graphics produced aid their reading, or conversely, hamper intelligibility? These are the main questions to be answered in this study. This research was based on the guiding principle and belief that the availability of clear and intelligible tactile graphics would greatly promote and enhance their use in the educational process for blind children.

The Perspective of Blind Readers

Blind students in SMPKS seemed to show a negative attitude towards tactile graphics. During an interview session with them on the effectiveness of tactile graphics, statements such as "tak suka bacalah" and "tak faham langsung" (meaning "don't like to read", and "incomprehensible") were uttered. More specifically, throughout the interview, words such as, "tak jelas" (not clear), "bercampur-campur" (mixed up), "kecil-kecil" (too small) and "terpadam" (erased) constantly cropped up. Perhaps these words aptly describe their distaste for tactile graphics.

On the subject of examination questions which contain tactile diagrams, one of the interviewees responded, "Orang yang buat sahaja tahu, kita tidak", meaning, "Only the one who prepared them knows, we don't". They also took the opportunity to vent their frustrations about teachers who blamed them for not trying hard enough, when in such cases, there was no way they could figure out what the diagrams represented. A girl mentioned that she never asked for fear of being reprimanded. She chose to keep quiet, throw things, or slam the brailler down, depending on the extent of her frustration.

These anecdotes suggest that the quality of tactile graphics made for the students is questionable. From the researcher's perspective, establishing and highlighting this concern is not enough. A systematic study is required to identify exactly where the tactile graphics have failed them.

A Case Study on Intelligibility of Tactile Graphics

This is a case study to identify the perception of subjects regarding the intelligibility of tactile graphics they had used at school. The students of SM Pendidikan Khas (Cacat Penglihatan) Setapak (SMPKS) had been identified as respondents for this study.

Five dimensions which contribute to the intelligibility of tactile graphics were targeted for study: the formatting of information, the tactual clarity of features, the appropriateness of tactile symbols, the simplicity of design, and the availability of instruction and reading cues. The researcher intended to give an informed indication of the extent to which tactile graphics made for the blind students of the school had complied with these dimensions of intelligibility. A review of literature was made to gather information on design aspects recommended by academicians and professional transcribers that make tactile graphics intelligible to the blind. Twenty-eight specifications were categorized into the respective dimensions, which best describes them, in developing a survey questionnaire for the intended study.

The questionnaire comprised two sections: the first focused on respondents' demographic factors, and their general perception on the intelligibility of tactile graphics; the second, a 28-item questionnaire marked on a 4-point Likert scale (Strongly Agree, Agree, Disagree and Strongly Disagree) elicited respondents' perceptions on the extent to which the dimensions and specifications for designing tactile graphics have been met. An open-ended question was included to give respondents a chance to express their opinions on the same subject. In the wording of the questionnaire, care had been taken to ensure that each question does not thwart the original instruction or recommendation put forth by its credited sources. Also, it was important to ensure the gist of each item could be properly understood by the sample subjects. For this purpose, the instrument was vetted by a panel of four visually impaired teachers of SMPKS. From the survey data, the reliability coefficient of the questionnaire was computed with the Guttman Split-half procedure, and this revealed a favorable value of .63 with an alpha value of .70 for part 1, and an alpha value of .65 for part 2.

As all the 30 respondents were exclusively braille users, the questionnaire was presented orally, as well as in braille form. No time limit was set because this could affect the pupils' concentration. There was an air of official purpose in this exercise to ensure total commitment to the task, but not to the extent of intimidating the respondents. As part of this mixed-method case study, the researcher had also conducted two interview sessions with selected respondents.

The Survey Respondents

The age range of the respondents is between 13 to 23 years old. The school hostel eaters for students from Form One to Upper Six. The minimum age of 13 agrees with the age of entry into SMPKS at Form One. However the maximum age of respondents picked for this study is 23, well above the normal age of an Upper Six-student (19) due to late blindness. There were 13 (43.3%) boys as compared to 17 (56.7%) girls. This proportion roughly reflects the gender make up of the student population in SMPKS. In this survey there were 14 (46.7%) adventitiously blind (late blind) respondents as opposed to 16 congenitally blind ones. Twenty-six (86.7%) of the respondents have had 8 or more years of education in special schools, as opposed to only 4 (13.3%) for those who had had 5 years and below.

Demographic Characteristics and General Perception of Intelligibility

Generally, more participating students recorded that tactile graphics were favorably intelligible to them than those who did not. Although only two (6.6% of the whole) responded that tactile graphics are highly intelligible to them, the majority of the survey participants (17 or 56.7%) rated tactile graphics as intelligible. The rest (11 or 36.7%) feel that they are not intelligible. Quite sensibly, not one of the respondents rated tactile graphics as not intelligible at all.

Employing the Pearson chi-square test to establish significant relationships between six demographic characteristics and perceived intelligibility of tactile graphics resulted in negative findings. There seems to be no significant association between respondents' age, gender, status of blindness, education level, years enrolled in special school, and years using tactile graphics, with their perception of whether tactile graphics were intelligible or unintelligible to them. This shows that their perception of the intelligibility of tactile graphics is independent of the demographic variables which defined them.

Students' Perception of the Intelligibility of Tactile Graphics

The four-point Likert scale of the questionnaire was transformed into an interval score of between 4 marks for 'strongly agree' (implying that the specification evaluated on is highly complied with) and 1 mark for 'strongly disagree' (implying otherwise). Based on this scoring scheme, the mean score derived from the respondents' general perception and the 28-item survey questionnaire revealed an overall mean of 2.70 (67.5% out of the maximum score of 4 marks) and 2.59 (64.8%) respectively, as shown in Table 1.

Table 1
Perception Mean and Test Mean Statistics

Characteristic	Mean	*SD*
Perception Mean	2.70	.60
Test Mean	2.59	.35

Pearson's Correlation r-value .51, (p<.01)

The Pearson's Correlation statistics between Test Mean and Perceived Mean Score revealed a .51 value that is greater than the critical *r* value of .46 at a significance level of .01 (2-tailed). This shows that the two variables are significantly correlated and it is fairly reliable to predict one variable from the outcome of the other.

According to Table 2, of the five dimensions under study, the formatting of information in tactile graphics was deemed most favorably complied with. This dimension garnered a mean score of 2.81 (70.3%). Next was tactual clarity, which scored 2.77 (69.3%). The third dimension which scored above the overall mean was appropriateness of symbolization, with a mean score of 2.72 (68.0%).

Two dimensions received scores which collectively fell below the overall mean. They were the simplicity of design (2.40, or 60.0%) and the availability of adequate reading cues and instructions (2.37, or 59.3%). It could thus be concluded that more attention should be given to these two dimensions when designing tactile graphics for the blind students.

Table 2
Dimension Score Statistics (in Relation to Mean Score of General Perception and Total Test Mean)

Dimension	Mean	*SD*
Dimension 1	2.81	.48
Dimension 4	2.77	.44
Dimension 5	2.72	.70
General perception	2.70	.60
Test mean	2.59	.35
Dimension 2	2.40	.49
Dimension 3	2.37	.51

Specification Compliance

Employing the median rating score of 2.54 as the cut-off point to break the items into two groups, the upper group garnering scores from 2.57 to 3.30 can be considered as favourably complied items. The lower group comprising scores from 2.00 to 2.53, are considered less favourably complied items. The upper group representing 14 items complying favorably with the specifications in order of merit is described in Table 3.

Table 3
Score Statistics of Favorable Items

Item	Mean	*SD*
Orientation of graphic	3.30	.79
Editing of extraneous information	3.23	1.07
Controlled use of text	2.90	.92
Uniform alignment of text and labels	2.90	1.09
Adequate explanation and instruction	2.87	.90
Controlled use of textures	2.80	.81
Proper sequencing of information	2.77	.86
Clarity of lines	2.73	.94
Availability of extra labelling	2.73	.87
Graphic size	2.70	.75
Availability of keys and legends	2.70	.95
Less prominent lead lines	2.67	.84
Accessible location of graphic	2.63	.72
Availability of starting points	2.57	1.17
Total Test Mean	2.82	.21

The lower group comprises 14 less favorably complied items, and they are as listed in Table 4.

Table 4
Score Statistics of Less Favorable Items

Item	Mean	*SD*
Orientation of graphic	3.30	.79
Restructuring of graphics into parts	2.53	1.01
Discrimination of positive and negative spaces	2.47	.94
Discernable shapes within graphics	2.43	.90
Rescaling size of graphic components	2.40	.97
Suitable choice of symbols	2.40	.77
Shapes are texture-filled	2.40	.86
Braille dots not used as textures	2.40	.97
Relief or multiple height treatment	2.37	1.00
Unambiguous intersection of lines	2.37	.89
Correct use of arrows	2.27	.94
Adequate spacing between symbols	2.27	.91
Distinguishable Textures	2.20	1.00
Consistency of symbolization	2.00	.98
Total Test Mean	2.36	.14

CONCLUSION

The general perception of the students on the intelligibility of tactile graphics (scoring a mean of 2.70, or 67.5% against the highest score of 4 marks) seems fairly good. The mean score obtained from a more systematic evaluation through the use of the 28-item test questionnaire falls just a little behind at 2.59 or 64.8%. These findings seem contrary to the apparently bleak observations declared by Aldrich and Sheppard (2002) and many teachers of the blind.

Nevertheless, because the questionnaire is essentially a compilation and distillation of criteria for making tactile graphics more intelligible to the blind, it can serve as a guideline for designing tactile graphics in future. Gardner (1996) pointed out that tactile graphics need to be presented in an informational way, and not as a guessing game. Consequently, this study has succeeded in listing out the dimensions and specifications which are not deemed favorably complied with so that teachers and other makers of tactile graphics know what to focus on in future. This study has also given users of tactile graphics a chance to voice out their opinions and describe their need for better intelligibility.

For continuous improvement, teachers should regularly gather feedback on the tactile graphics developed for students' use. Aldrich and Sheppard (2002) advise teachers to prompt users to think about the relative merits of the tactile graphics and discuss ways of improving them. On the macro scale, the Special Education Department should conduct more meetings and workshops to appraise the tactile graphics in braille books and take appropriate measures in overcoming the limitations identified in this study.

Ultimately, this research exercise is not meant to put a numerical value on the level of intelligibility of tactile graphics, but to pinpoint areas of weaknesses for improvement. After all, as stated by Rossi, Howard and Wright (1979), all educational resources must be subjected to constant examination to maintain their worth in the education of our children. With more studies and work given to improving the intelligibility of tactile graphics, one day remarks such as "Only the one who prepared them knows, we don't", will be a thing of the past.

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