Guidelines for designing tactile maps for orientation and mobility in buildings

Diretrizes para o design de mapas táteis para orientação e mobilidade em edifícios

Isabela Guesser Schmitt, Vanessa Casarin

tactile maps, guidelines, orientation, mobility, accessibility

Accessibility for people with disabilities is essential to ensure autonomy and inclusion. Tactile maps play a fundamental role in orientation and mobility, allowing the environment to be read through touch. However, the dispersion of guidelines and the lack of standardization in their design can compromise the efficiency of this type of assistive technology. In this sense, we carried out an Integrative Literature Review to identify guidelines for the design of tactile maps for orientation and mobility in buildings. The databases consulted were the CAPES Theses and Dissertations Catalog, CAPES Periodicals Portal, Web of Science, Scopus and Scielo, resulting in the analysis of 34 documents. The results gathered guidelines on support, location of the map in the building, reading position, map size, scale, symbols and characters, and legend, indicating that standardized elements or more specific and experimentally validated guidelines are necessary to ensure the usability of the maps.

mapas táteis, diretrizes, orientação, mobilidade, acessibilidade

A acessibilidade para pessoas com deficiência é essencial para garantir autonomia e inclusão. Os mapas táteis desempenham um papel fundamental em orientação e mobilidade, permitindo a leitura do ambiente por meio do tato. No entanto, a dispersão de diretrizes e a falta de padronização em seu design podem comprometer a eficiência desse tipo de tecnologia assistiva. Nesse sentido, realizamos uma revisão integrativa da literatura com o objetivo de identificar diretrizes para o design de mapas táteis voltados à orientação e mobilidade em edifícios. As bases de dados consultadas foram o Catálogo de Teses e Dissertações da CAPES, o Portal de Periódicos da CAPES, Web of Science, Scopus e SciELO, resultando na análise de 34 documentos. Os resultados reuniram diretrizes relacionadas ao suporte, à localização do mapa no edifício, à posição de leitura, ao tamanho do mapa, à escala, aos símbolos e caracteres e à legenda, indicando que elementos padronizados ou diretrizes mais específicas e validadas experimentalmente são necessários para garantir a usabilidade dos mapas.

1 Introduction

Inclusion and accessibility for people with disabilities have become increasingly relevant issues in the global context where around 16% of the world's population have some type of disability (Fundação Oswaldo Cruz [Oswaldo Cruz Foundation, Fiocruz], 2023). In Brazil, the number of people with visual impairment, including total blindness and low vision, reaches almost 7 million, according to the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística [IBGE], 2021). This highlights the need to promote solutions that guarantee autonomy and accessibility for this group.

Visual impairment directly impacts spatial perception and navigation in space, requiring people to activate other senses to orient themselves and move correctly (Gibson, 1966). In this context, tactile maps serve as fundamental tools to visual impaired autonomy in navigating in space, enabling spatial understanding through touch (Ungar, Blades, & Spencer, 1996; Tinti et al., 2018).

For a map to be effectively interpreted, the user must be able to read it efficiently, (Bernardi, 2007). Papadopoulos et al. (2017) stress that despite the advantages of using tactile maps for orientation and mobility, a series of limitations have been pointed out in the literature, such as the amount of information to be processed.

While basic guidelines for designing tactile maps exist (Lobben & Lawrence, 2012), they are often vague. The absence of standardization compromises the usability of these maps, contributing to communication barriers (Almeida, 2022; Bernardi, 2007; Ferreira & Silva, 2014).

Thus, Information Design plays a crucial role in improving tactile maps. Reuniting existing guidelines is necessary to understand how it is possible to advance in designing information for tactile maps for mobility.

In this context, this article seeks to identify the main guidelines for designing tactile maps for orientation and mobility in buildings, according to the literature.

2 Methodological procedures

This study was conducted through an Integrative Literature Review, a method that allows the synthesis of knowledge on a given topic, enabling a critical and comprehensive analysis of existing publications (Whittemore & Knafl, 2005).

The search was conducted on the following databases:[1] CAPES Theses and Dissertations Catalog, CAPES Periodicals Portal, Web of Science, Scopus, and Scielo. Other key references relevant to the study theme were included.

A total of 34 studies were included, which addresses the design of tactile maps aimed at orientation and mobility, with an emphasis on primary and experimental research. The exclusion criteria considered works that did not directly address the proposed theme. The data analysis was performed qualitatively, allowing the identification of guidelines, points of convergence and divergence between the studies, and gaps in the literature on the topic.

1 Search string: ("tactile map") AND ("orientation" OR mobility"), with no time restriction. The articles were selected in three stages: (1) reading of titles, (2) analysis of abstracts, and (3) full reading of the eligible texts.

3 Results and discussion

Guidelines for designing tactile maps aimed at orientation and mobility in buildings, summarized from the literature were structured into the following topics: characteristics of map holders, reading position and location of the map in the building, general size of the map, scale, symbols, embossed letters, Braille and legend.

3.1 Characteristics of map holders

Tactile maps for orientation and mobility can be fixed or portable. This topic deals with fixed maps, installed in internal or external strategic locations. ISO 19028 (2016) recommends that maps on inclined floor stand map holders be up to 60 cm by 100 cm wide, with at least 90 cm of free space from the floor for access by people in wheelchairs. Those installed on the wall should have the center line, preferably 140 cm from the floor and within 60 cm of height.

Regarding the material, glossy surfaces should be avoided to prevent reflections and glare (ISO 19028, 2016). Matte finishes are recommended, as they reduce unwanted effects of light and facilitate the sliding of fingers during tactile reading (ISO 19028, 2016; Rowell & Ungar, 2003).

3.2 Reading position and location of the map in the building

The orientation of a fixed map must ensure that its directions correspond to the real environment (Braille Authority of North America [BANA], 2022). It must include a tactile and visual identifier, such as "You are here," highlighted on the map.

ISO 19028 (2016) recommends that the indication of the current location be aligned exactly with the directions and real position of the place where the map is installed. In buildings with multiple floors, each map must maintain the same position and orientation on all floors. The use of the symbol (N) to indicate North is not mandatory, but recommended when useful for orientation (ISO 19028, 2016).

ISO 19028 (2016) also stresses the importance of ensuring that people with visual impairments can easily locate tactile maps in the building, whether through tactile floors or audio guidance, or by installing them in fixed locations near elevators and stairs, among others. NBR 9050 (ABNT, 2020) determines that accessible plans or maps be installed close to the main entrance of the building or immediately after it.

3.3 General size of the map

The size of the map affects its readability and depends on the area represented, level of detail, and purpose (BANA, 2022). For portable maps aimed at mobility, it is recommended that their size be smaller than the span of two outstretched hands, facilitating tactile exploration with less effort (Edman, 1992). In this context, Rowell & Ungar (2003) highlight that A4 and A3 formats are widely used globally, as they allow efficient reading by providing a tactile frame of reference, since the reader holds the map with their hands.

Tactile reading is similar to viewing through a small 1-cm hole, which makes it difficult to relate distant points and reinforces the need to limit the size of maps (The NSW Tactile and Bold Print Mapping Committee, 2006). In the case of fixed maps, ISO 19028 (2016) recommends that maps installed on inclined floor stand holders be up to 60 cm × 100 cm wide, that is, the map and legend have to fit within this dimension.

3.4 Scale

Scale defines the relationship between the dimensions of something real and its representation. In tactile maps, the scale varies according to the amount of information and the size of the symbols. Trevelyan (1980) notes that, unlike visual maps, the scale in tactile maps can be adjusted to avoid illegibility, increasing distances between symbols so that the reader can distinguish them as separate.

Bentzen & Marston (2010) state that the scale in tactile maps does not need to be consistent across all its parts to be effective, as they allow for the simplification and displacement of elements. In addition, non-rounded scales – such as 1:185 or 1:230 – are common, as the aim is to make the most of the available space on a sheet (Wiÿckowska et al., 2012).

For most readers, the correct relationship between elements is more important than the exact scale (BANA, 2022). Wiedel & Groves (1969) suggest that linear scales can help in comparing distances, but may be unnecessary at smaller scales. Distance measurement, done with a Braille ruler, is considered an advanced resource (BANA, 2022).

3.5 Symbols

The information on a tactile map is expressed through a graphic system composed of symbols, formed by points, lines, and areas. In addition to the symbol typology (point, line or areal), these can vary depending on their size, value, texture, color, orientation, and shape (Dent, 2009).

Point symbols are used to designate specific locations of objects, are symbolic and do not necessarily indicate the shape or size of the object (Edman, 1992). Line symbols, in turn, indicate the location and direction of an element, and are composed of lines of different sizes and shapes (continuous, dashed, double, and so on). Areal symbols represent textured areas on a map, indicating the shape, size, and location of elements (Edman, 1992).

By relating these definitions to practical examples, we can visualize the following on a tactile map: point symbols, such as the indication "You are here"; line symbols, which can indicate the position of walls or paths; and areal symbols, used to delimit areas of vegetation or other specific surfaces.

3.5.1 Maximum number of distinct symbols on a map

According to Trevelyan (1980), the choice of symbols on a tactile map is based on two main criteria: discriminability and discernibility. Discriminability refers to the ease with which a symbol can be recognized as distinct from another by touch, while discernibility is related to how the design of a symbol facilitates the memorization of its meaning.

Thus, when selecting tactile symbols, it is essential to balance the representation of different types of information with the reader's ability to recognize tactile patterns and memorize the meaning of each symbol (Trinh; Manduchi, & Giudice, 2023).

There is no consensus in the literature on the ideal maximum number of symbols on a tactile map. In their experiments, Gil & James (1973) found that users could discriminate up to 13 point symbols and 10 line symbols, and Nolan & Morris (1971) suggested a maximum of eight areal symbols on a tactile map. Rowell & Ongar (2003) recommend including a maximum of 10 to 15 distinct symbols on a tactile map.

Even when all symbols are identifiable, too much information may hinder usability (Berlá & Murr, 1975), overloading memory and obscuring the most relevant content.

3.5.2 Minimum distance between symbols

The minimum distance between two symbols on tactile maps have to be greater than that required for visual perception, due to the characteristics of tactile perception (Edman, 1992). According to the author, for two symbols to be recognized tactilely, the distance between them have to be at least 3 mm, equivalent to the approximate distance between two Braille cells.

Klatzky & Lederman (2003) point out that, due to the limited resolution of tactile detection, point symbols have to be separated by at least 2.4 mm. Nolan & Morris (1971) recommend a minimum distance of 2.3 mm between distinct symbols, to ensure their effective tactile differentiation.

3.5.3 Elevation (relief) of symbols

Maps that use point, line, and areal symbols with different relief levels are more easily understood than those in which the relief is similar for all symbol typologies. This is because tactile perception is highly sensitive to differences in elevation (Edman, 1992).

It is recommended that areal symbols have the lowest elevation level, line symbols a little higher level, and point symbols have the highest one (Edman, 1992). James (1982) established specific parameters for symbol elevation: Braille (0.5 mm), areal symbols (0.5 to 1 mm), line symbols (1 mm), and point symbols (1.5 mm). NBR 9050 (ABNT, 2020) suggests that texts in relief and tactile symbols, regardless of typology, have an elevation of between 0.8 mm and 1.2 mm.

ISO 19028 (2016) recommends higher elevation level for essential elements, such as stairs, elevators and bathrooms, and that building entrances and internal environments be highlighted and easily distinguishable.

3.5.4 Format of point symbols

Point symbols indicate the location of objects on tactile maps and may include Braille characters and embossed letters, as appropriate. The main recommendation is to prioritize simplicity, using basic geometric shapes, such as circles, squares, or triangles (Bris, 2001; Polak & Olczyk, 2010; ISO 24508, 2019).

According to Polak & Olczyk (2010), the most easily perceived point symbols are those with a simple and unfilled outline. Eriksson, Jansson, & Strucel (2003) recommend avoiding the use of symbols of the same format in filled and outlined versions on the same map.

Bris (2001) suggests that independent point symbols be distinct from those representing textured areas, even if they vary in size. ISO 24508 (2019) recommends that tactile symbols and characters be arranged vertically and positioned close to the objects they represent, maintaining spatial consistency on the map.

3.5.5 Size of point symbols

Point symbols must have dimensions suitable for fitting under the fingertips of the reader, ensuring tactile recognition of the symbol as a distinct unit (Edman, 1992). BANA (2022) recommends 6 mm, while ISO 19028 (2019) suggests 10 mm.

The differentiation between point symbols occurs through the variables of shape, contour and elevation, and it is recommended to differentiate between at least two of these variables (Edman, 1992). According to the author, sharp edges are more noticeable and generate faster responses than rounded edges. Jeohel (2007) indicates that elements with sharp edges generate a faster neurophysiological response compared to smooth edges. This effect can be used to improve the readability of tactile elements.

Regarding size, Jehoel (2007) found that symbols smaller than 3.9 mm are difficult to perceive, while symbols larger than 7.1 mm do not improve readability. For the author, the minimum size that provides reliable reading is 4.7 mm.

To highlight symbols, Edman (1992) recommends at least a 3-mm difference in height.

When symbols differ only in size or elevation, the difference between them have to be at least 25% to ensure effective distinction (Pick, 1980).

Excessively figurative (and complex geometric) symbols should be avoided (Edman, 1992). Simple shapes are preferred so that they can be understood rapidly. Embossed letters or Braille characters can be used to facilitate association with the object represented, such as a cross to symbolize a church or the letter "B" to indicate a Biology classroom.

3.5.6 Arrows

Arrows represent a type of symbol that is halfway between a point symbol and a line symbol (Edman, 1992). Their applications include indicating the slope of terrain, the direction of stairs (up or down), and signaling entrances or exits in buildings or environments.

As for the format, the ISO 19028 (2016) standard establishes that arrows must be composed exclusively of a shaft and an arrowhead, the latter being formed by a right angle of 90º. However, a restrictive use of arrows is recommended, as they can disorganize a map and confuse the reader if they are not essential (Edman, 1992).

3.5.7 Line symbols

Line symbols indicate direction and location of elements on the map, without representing actual width or height.

Nolan & Morris (1971) identified four characteristics that affect the discriminability of a line symbol, which can vary in continuity (solid or dotted/dashed), regularity (straight or wavy), complexity (single or double), and thickness (thin or thick).

The choice of line type should consider its function: structural lines need to be highlighted by thickness, texture or elevation, while information lines, used to indicate distances and directions, are often dotted (Edman, 1992). In addition, the simultaneous use of different types of lines in the same map requires caution. Certain combinations can cause confusion, as in the case of a single straight line and a double line with the same width and elevation. Pick (1980) recommends differences of at least 25% in width or height.

Jehoel (2007) suggests that the maximum thickness of single lines be 1.9 mm, given that higher values can be interpreted as double lines, and that double lines have a minimum spacing of 1 mm. Bentzen & Marston (2010) point out that single lines generate more precise mental images and take up less space compared to double lines.

Dashed lines, composed of spaced segments, require specific care, since the distance between the lines must be sufficient to differentiate between a dashed line and a continuous line.

Edman (1992) suggests that lines be between 6 and 9 mm long, with spacing equivalent to half the length of the line.

For a linear element to be distinguished, its minimum length must be approximately 13 mm, since smaller representations can be confused with point symbols (Loch, 2008). Nolan & Morris (1971) suggest that the minimum recognizable line length should range from 12.7 mm to 25.4 mm, although this rule does not apply to broken lines, such as dashed lines.

As for the dotted line pattern, the dots should have a diameter larger than 2 mm or smaller than 0.7 mm to avoid confusion with the Braille standard (The NSW Tactual and Bold Print Mapping Committee, 2006).

ISO 19028 (2016) recommends that the line width be approximately 10% of the overall size of the symbol or character, within the functional range of 0.5 to 3 mm, ensuring legibility.

3.5.8 Areal symbols

Areal symbols are used to delimit regions on maps, representing their shape, size, and location. Textures and patterns can be applied to different parts of the map, although the dimensions and contours of these areas vary (Edman, 1992). These elements are essential for identifying the limits of an area, facilitating tactile interpretation.

Edman (1992) highlights that rougher textures tend to stand out, becoming more prominent in relation to other areas. The author also suggests that the minimum size for textured areas is 13 mm.

According to The NSW Tactile and Bold Print Mapping Committee (2006), symbols are characterized by three dimensions: style (geometry of the elements), spacing (distance between the elements), and thickness (width of the elements). Levi & Schiff (1966) point out that variations in texture density are more noticeable than differences in shape or orientation, making tactile distinction more efficient.

3.6 Embossed letters

The most effective capital letters for use in relief include A, B, C, E, F, H, I, J, L, Q, P, R, S, T, U, Y and Z, according to a study by Schiff (1966), in which 14.2 mm characters were recognized with high accuracy. ISO 24508 (2019) recommends that the minimum size of tactile characters be 15 mm, while NBR 9050 (ABNT, 2020) establishes a variation of 15 to 50 mm, requiring that embossed texts be accompanied by Braille, ensuring accessibility.

ISO 24508 (2019) also suggests the use of simple characters, such as Arabic numerals and basic Latin characters, advising against serif or script fonts (cursive writing) due to the difficulty of tactile recognition.

3.7 Braille

Braille is a tactile writing and reading system with 63 symbols in relief representing letters, numbers, and punctuation marks, which follows strict standard of size to ensure legibility when included on maps (Edman, 1992).

Only a small portion of the visually impaired population understands Braille, and its size requirements can limit the density and design of tactile maps (Taylor et al., 2016). NBR 15599 (ABNT, 2008) emphasizes that not all blind people use Braille, as some may not have the necessary tactile sensitivity.

According to ISO 19028 (2016), Braille texts and characters in relief must be presented horizontally and cannot be arranged diagonally, in a curved or inverted format. To meet the needs of people with residual vision, the recommendation is to use enlarged texts in black, and marks printed in vibrant colors. In tactile maps structured in layers, such as those made with transparent plates, the organization can be optimized by positioning the Braille and tactile marks on the top layer, while the enlarged letters and colored marks are on the bottom layer, improving accessibility.

3.8 Legend

Tactile maps usually include a legend that provides information about the symbols represented accompanied by an explanation for each item listed.

The symbols are organized in a column on the left and their descriptions in Braille in the column on the right, and the columns should be close together for easy reading (Edman, 1992). The symbols for lines, points, and areas appear at the beginning of the legend and should be represented on the same scale used on the map (Edman, 1992). According to the author, the lines should be at least 13 mm long, and the textured areas in boxes measuring 13 × 13 mm, preferably larger.

The combinations of letters should be organized in alphabetical order and the numbers in numerical order. If the map includes the symbol "You are here," it has to be positioned as the first item in the legend (Edman, 1992; ISO 19028, 2016).

3.9 Summary

Table 1 presents a summary of the guidelines for designing tactile maps for orientation and mobility.

Table 1 Summary of guidelines.

Type of Media	Process stage
1. **Map holder characteristic**: defined by ISO 19028 and NBR 9050	ISO 19028 (2016), NBR 9050 (2020)
2. **Map size**: map and legend must be contained on a holder no larger than 60 × 100 cm	ISO 19028 (2016)
3. **Content**: it must follow the principle of simplicity and present only essential information to fulfill its function	Edman (1992)
4. **Scale**: it varies, does not need to be known, and may present distorted proportions for the allocation of symbols in a readable way	Trevelyan (1980), Bentzen & Marston (2010)
5. **Symbols**	
5.1 Types: linear, point and areal symbols	
5.2 Maximum number on a map: 10 to 15	Rowell & Ungar (2003), Gil & James (1973), Nolan & Morris (1971)

Table 1 Summary of guidelines. (continued)

Type of Media	Process stage
5.3 Minimum distance: 2.3 mm to 3 mm	Edman (1992), Nolan & Morris (1971)
5.4 Symbol height: Braille (0.5 mm), areal symbols (0.5 to 1 mm), line symbols (1 mm), and point symbols (1.5 mm)	James (1982)
5.5 Minimum size of point symbols: 4.7 mm to 5.1 mm	Edman (1992), Jehoel (2007)
5.6 Format of point symbols: simple geometric shapes, Braille characters, and embossed capital letters can also be included in this symbol typology	Edman (1992), Bentzen & Marston (2010)
5.7 Minimum length of linear symbols: 12.7 mm to 25.4 mm	Edman (1992)
5.8 Minimum thickness of linear symbols: 0.5 mm to 3 mm	ISO 24508 (2019)
5.9 Variations of linear symbols: solid, dotted, and dashed. Single lines generate more precise mental images compared to double lines	Edman (1992), Bentzen & Marston (2010)
5.10 Minimum size of areal symbols: 13 mm	Edman (1992)
5.11 For variations in areal symbols, the geometry, spacing, and thickness of the elements can be differentiated	Levi & Schiff (1966)
6. **Use of letters**: most commonly used capital letters in relief: A, B, C, E, F, H, I, J, L, Q, P, R, S, T, U, Y and Z. Use of sans serif fonts. Minimum height of tactile characters: 15 mm	Schiff (1966), ISO 24508 (2019), NBR 9050 (2020)
7. **Use of Braille**: Including Braille on maps requires adequate space to accommodate the symbols legibly	Edman (1992)
8. **Legend**: must contain the information present on the map: symbols (point, linear and areal), as well as possible combinations of letters and numbers, accompanied by an explanation for each item listed	Edman (1992)

4 Conclusions and final considerations

The search for effective standardization of tactile maps for orientation and mobility in buildings still faces challenges, despite the advances made and initiatives developed over the last few decades. Whether in relation to the symbology or the materials used in their production, standardization requires the unification of principles that ensure consistency and quality, regardless of their designer.

Although there are national and international guidelines, such as ISO standards and regional standards adopted by different countries, the lack of a global consensus still limits the dissemination and application of these standards. The dispersion of initiatives, the diversity of materials and techniques used and language barriers are factors that hinder the consolidation of a standardized model. The literature indicates that the unification of principles and the adoption of parameterized design rules can contribute to improving the quality and accessibility of tactile maps.

However, for effective standardization advancement, it is essential to validate the proposed standards through direct experimentation with the target audience, ensuring that the tactile maps meet the real needs of users.

Acknowledgment

The authors would like to thank CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior) for funding the research.

References

Almeida, E. A. M. (2022). *Arquitetura tátil: diretrizes para dispositivos tridimensionais de orientação espacial*. Dissertação (Mestrado). Universidade Federal da Paraíba, João Pessoa.

Associação Brasileira de Normas Técnicas. (2008). *NBR 15599: Acessibilidade a edificações – Sistema de sinalização tátil*. ABNT.

Associação Brasileira de Normas Técnicas. (2020). *NBR 9050: Acessibilidade a edificações, mobiliário, espaços e equipamentos urbanos*. ABNT.

Bentzen, B. L., & Marston, J. R. (2010). Teaching the use of orientation aids for orientation and mobility. In W. R. Wiener, R. L. Welsh, & B. B. Blasch (Eds.), *Foundations of Orientation and Mobility: Instructional Strategies and Practical Applications* (3rd ed., pp. 296–323). AFB Press.

Berlá, E. P., & Murr, M. J. (1975). The effects of noise on the location of point symbols and tracking a line on a tactile pseudomap. *The Journal of Special Education*, *9*(2), 183–190. https://doi.org/10.1177/002246697500900212

Bernardi, N. (2007). *A aplicação do conceito do Desenho Universal no ensino de arquitetura: o uso de mapa tátil como leitura de projeto*. Tese (Doutorado). Universidade Estadual de Campinas, Campinas.

Bris, M. (2001). *Guide de l'acheteur public de produits graphiques en relief à l'usage des personnes déficientes visuelles*. Ministère de l'Économie, des Finances et de l'Industrie.

Braille Authority of North America. (2022). *Guidelines and standards for tactile graphics*. BANA.

Dent, B. D. (2009). *Cartography: Thematic Map Design*. Brown Publishing Company.

Edman, P. K. (1992). *Tactile graphics*. American Foundation for the Blind.

Eriksson, Y., Jansson, G., & Strucel, M. (2003). *Tactile maps – Guidelines for the production of maps for the visually impaired*. The Swedish Braille Authority.

Ferreira, M. E. dos S., & Silva, L. F. C. F. da. (2014). A aplicação das tecnologias de prototipagem rápida na confecção de matrizes táteis. *Boletim de Ciências Geodésicas*, *20*(2). https://doi.org/10.1590/S1982-21702014000200024

Fundação Oswaldo Cruz [Fiocruz]. (2023). *16% da população mundial têm alguma deficiência*. https://www.fiocruzbrasilia.fiocruz.br/16-da-populacao-mundial-tem-alguma-deficiencia/

Gibson, J. J. (1996). *The senses considered as perceptual systems*. Houghton Mifflin.

Gil, J. M., & James, G. A. (1973). A study on the discrimination of tactual point symbols. *American Foundation for the Blind Research Bulletin*, *26*, 19–34.

Instituto Brasileiro de Geografia e Estatística [IBGE]. (2021). Um em cada quatro idosos tinha algum tipo de deficiência em 2019. *Agência de Notícias IBGE*. https://agenciadenoticias.ibge.gov.br/agencia-noticias/2012-agencia-de-noticias/noticias/31447-um-em-cada-quatro-idosos-tinha-algum-tipo-de-deficiencia-em-2019

International Organization for Standardization [ISO]. (2016). *ISO 19028 – Accessible design – Information contents, figuration and display methods of tactile guide maps*. International Organization for Standardization.

International Organization for Standardization [ISO]. (2019). *ISO 24508 – Ergonomics – Accessible design guidelines for designing tactile symbols and characters*. International Organization for Standardization.

James, G. A. (1982). Mobility maps. In W. Schiff & E. Foulke (Eds.), *Tactual perception: A sourcebook* (pp. 334–363). Cambridge University Press.

Jehoel, S. (2007). *A series of psychological studies on the design of tactile maps*. Tese (Doutorado). University of Surrey, Guilford.

Klatzky, R. L., & Lederman, S. J. (2003). Touch. In A. F. Healy & R. W. Proctor (Eds.), *Handbook of psychology: Experimental psychology* (Vol. 4, pp. 147–176). John Wiley & Sons, Inc.

Lobben, A., & Lawrence, M. (2011). The use of environmental features on tactile maps by navigators who are blind. *The Professional Geographer*, *64*(1), 95–108. https://doi.org/10.1080/00330124.2011.595619

Loch, R. E. N. (2008). Cartografia tátil: mapas para deficientes visuais. *Portal da Cartografia*, *1*(1).

Nolan, C. Y., & Morris, J. E. (1971). *Improvement of tactual symbols for the blind* (Final Report, Project No. 5-0421). American Printing House for the Blind.

Papadopoulos, K., Koustriava, E., & Koukourikos, P. (2017). Orientation and mobility aids for individuals with blindness: Verbal description vs. audio-tactile map. *Assistive Technology*, *30*(4), 191–200. https://doi.org/ 10.1080/10400435.2017.1307879

Pick, H. L. (1980). Tactual and haptic perception. In R. L. Welsh & B. B. Blasch (Eds.), *Foundations of orientation and mobility* (pp. 89–114). AFB Press.

Polak, M., & Olczyk, M. (2010). Redakcja tyflokartograficzna. *Przegląd Tyflologiczny*, 1–2, 40–41.

Rowell, J., & Ungar, S. (2003). The world of touch: An international survey of tactile maps. Part 1: Production. *British Journal of Visual Impairment*, *21*(3), 98–104. https://doi.org/10.1177/026461960302100303

Rowell, J., & Ongar, S. (2003). The world of touch: an international survey of tactile maps. Part 2: Design. *British Journal of Visual Impairment*, *21*(3), 105–110. https://doi.org/10.1177/026461960302100304

Schiff, W. (1966). *Manual for the construction of raised line diagrams*. Recording for the Blind.

Taylor, B., Dey, A., Siewiorek, D., & Smailagic, A. (2016). Customizable 3D printed tactile maps as interactive overlays. In *Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility* (ASSETS '16) (pp. 71–79).

The NSW Tactual and Bold Print Mapping Committee. (2006). *A guide for the production of tactual and bold print maps* (3rd ed.). Sydney.

Tinti, C., Chiesa, S., Cavaglia, R., Dalmasso, S., Pia, L., & Schmidt, S. (2018). On my right or on your left? Spontaneous spatial perspective taking in blind people. *Consciousness and Cognition*, *62*, 1–8. https://doi.org/10.1016/j.concog.2018.03.016

Trevelyan, S. (1980). *Development and assessment of a tactile mobility map for the visually impaired* (Dissertação M. A.). Oxford University.

Trinh, V., Manduchi, R., & Giudice, N. A. (2023). Experimental evaluation of multi-scale tactile maps created with SIM, a web app for indoor map authoring. *ACM Transactions on Accessible Computing*, 16(2), art. 13, 1–26. https://doi.org/10.1145/3590775

Ungar, S., Blades, M., & Spencer, C. P. (1996). The construction of cognitive maps by children with visual impairments. In J. Portugali (Ed.), *The construction of cognitive maps* (pp. 247–273). GeoJournal Library, Vol. 32. Springer.

Whittemore, R., & Knafl, K. (2005). The integrative review: Updated methodology. *Journal of Advanced Nursing*, *52*(5), 546–553. https://doi.org/10.1111/j.1365-2648.2005.03621.x

Wiÿckowska, E., Chojecka, A., Mikołowicz, B., Fuksiński, C., Mendruń, J., Olczyk, M., & Rudnicka, M. (2012). Standardy tworzenia oraz adaptowania map i atlasów dla niewidomych uczniów.

Wiedel, J. W., & Groves, P. A. (1969). *Tactual mapping: design, reading, and interpretation*. Department of Health, Education, and Welfare.

About the authors

Isabela Guesser Schmitt
isagschmitt@gmail.com
Federal University of Santa Catarina
Florianópolis, SC

Vanessa Casarin
vanessa.casarin@ufsc.br
Federal University of Santa Catarina
Florianópolis, SC

Submission date/*Artigo recebido em*: 18/5/2025
Approvement date/*Artigo aprovado em*: 10/12/2025