International Cartographic Association
Association Cartographique Internationale

# Methodological study of tactile signs readability

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**Keywords:** tactile maps, tactile signs, sign theory, tactile sign testing, historical gardens

**Abstract:**

A lot of tactile maps designed in laboratories are often not used by people with visual impairment (PVI) in their daily lives. This problem results from the lack of cooperation between the authors and the recipients of tactile maps at the stage of maps creation, and thus the lack of appropriate simplification and adaptation of the content. As the result, these maps are not legible for PVI. In order to eliminate such problems, the development of tactile maps should be largely participatory - PVI should be involved in all stages of developing the map concept, creating its content resources and tactile signs. Of particular importance is the stage of testing the readability and communicativeness of tactile maps, and especially checking tactile signs as the most important elements of the map, which carriers of information transmitted using a tactile map.

In previous studies, we can find issues related to the standardization and parameterization of tactile signs taking into account the specificity of tactile perception. However, verification of the assumptions with the participation of PVI mainly concerned the comparison of tactile maps production techniques, the assessment of the distances between the signs, ensuring their perception as separate, and checking the usability of tactile maps for orientation purposes. The disadvantage of most testing sessions was the homogeneity of the test groups, for example, only students or only primary school students participated in them, and not the target audience. The methodical study of tactile cartographic symbols was not the goal of previous scientific research, testing only served a subordinate role in relation to the overarching research goals. Moreover, different procedures were practiced, depending on what the testing was to be used for, which translated into selectivity in the selection of material, tactile signs, tasks, testing only one type of geometry (e.g. only point symbols). The researchers pointed this as a limitation of the procedures used, recommending the need to continue the research in this area.

In view of the above, **the aim of our research was to methodically check the readability of cartographic signs designed for tactile maps.** A methodical approach to signs assessment is particularly important in the increasingly popular development of low-cost tactile maps, e.g. with the use of 3D printing.

In the research, we assumed that the methodology of examining signs should be based on **two foundations - people and signs.** Personal foundation is related to the diversity of the group of testers in terms of socio-demographic characteristics related to the specificity of visual disability (moment of its occurrence, functional consequences, degree of rehabilitation) and tactile skills, including the techniques used (e.g. in the field of cooperation of both hands in the process of tactile cognition). Sign foundation is related to the focusing on the sign, as a carrier of information transmitted by means of a tactile map. For this purpose, we proposed the use of the theory of the construction of a cartographic sign - **Peirce's sign triad**, which treating the sign as a semiotic object. In the case of maps and cartographic signs, the laws of semiotics include three types of semiotic dependencies: semantic dependencies, concerning the relations between signs and reality, syntactic dependencies, concerning the relations between signs, and pragmatic dependencies, concerning the relations between signs and map recipients. Therefore, we divided the signs testing methodology into two stages:

- **the study of semantic and syntactic relations**, it means testing of signs in isolation. For this purpose, it was proposed to develop matrices for point, line and area signs, containing designed signs duplicated in columns and rows. The test consists in recognizing signs and their meaning and distinguishing between signs;
- **the study of pragmatic relations**, including the study of signs in context, i.e. in the vicinity of other signs. For this purpose, it was proposed to develop pseudomaps containing various combinations of the mutual position

Abstracts of the International Cartographic Association, 6, 174, 2023.
31st International Cartographic Conference (ICC 2023), 13–18 August 2023, Cape Town, South Africa.
https://doi.org/10.5194/ica-abs-6-174-2023 

of signs of different geometry. The research consists in finding signs and building a narrative about the content presented on pseudomaps.

The summary of each stage of the research is the assessment of the performance of the tasks and the questionnaire completed by the testers. They include the assessment of the ease of implementation of the tasks, comments on the designed signs, suggestions for changes, as well as free statements of testers.

The proposed methodology was tested on the example of tactile cartographic signs developed for set of **tactile maps of historical gardens in various garden design styles**: Baroque, Renaissance, English, Romantic and Japanese. For these maps, 30 point, 13 line and 17 area tactile cartographic signs were designed. For content elements repeated in different styles and at different levels of tactile maps detail, the same signs were adopted. Before starting the tests, two PVI were consulted in order to eliminate gross errors of illegibility of the designed signs. After taking into account their comments, the signs set was ready for testing.

In cooperation with the Polish Association of the Blind (PZN), a group of 20 testers was selected, diverse in terms of age, visual impairment, experience working with tactile maps, etc.

For the purposes of **examining signs in isolation**, three matrices were developed. They contained developed tactile cartographic signs, which were duplicated in rows and columns, comprising a total set of: 120 point signs, 52 line signs and 60 area signs. Three tasks were prepared, including the recognition of 30 point signs, 13 line signs and 1 area signs in isolation. The subject's task was to assign a sign from the matrix to its explanation in the legend. The duration of the study with one participant was 60 minutes.

The test results showed that 11 out of 30 proposed point signs did not cause any problems for the subjects and they can be used without further modifications. Most signs required minor modifications, e.g. enlargement. Among the point signs, there were some that were too similar to each other. Originally, they differed only in one or two haptic variables, e.g. only rotation. During modifications, the number of haptic variables differentiating problematic signs was increased. Among the 13 tested line signs, as many as 10 did not cause any major problems for the testers. 3 reserve characters were proposed, so the line signs set did not require major modifications. Of the 16 area signs tested, 7 caused no problems for the subjects. Respondents indicated pairs of signs too similar to each other. Based on the testers' suggestions, signs modifications were introduced, mainly consisting in increasing texture elements or spacing between them.

In order **to examine the signs in context**, 7 pseudomaps imitating tactile maps of gardens in different design styles, using corrected signs, were developed. 8 tasks were prepared, which included finding signs on pseudomaps, as well as telling about what is on the maps (building a narrative). The duration of the study with one participant was 90 minutes.

Results of the second session proved the correctness of the previously introduced modifications. This time all the symbols have been placed on pseudomaps in a context with their corresponding meanings. All of the 25 point symbols were found legible by the study participants. The same applies to the 14 proposed line symbols. Study participants identified them with ease. The only modification that we have introduced after the second session is to how the line symbols appear on a map legend (curved fragments rather than polylines). Area symbols were the most problematic ones – study participants pointed out that some of them are too similar to each other. However, since the symbols were tested in a context, we came to a conclusion that there are particular pairs of troublesome signs. Instead of modifying their geometries, we have simply assigned different meanings to such symbols so that it will be now very unlikely for such problematic pairs of area symbols to appear together on a single map. We still had to further modify one of the symbols and exclude another one.

The results of the tests and comments from the testers' showed that the results obtained are not only satisfactory, but also met with great appreciation of the testers. Their satisfaction concerned the very fact of asking them for their opinion, taking their opinions into account, as well as striving to develop a universal solution by correcting the signs in a way that takes into account the divergent comments of testers of different ages, with different visual impairments and different competences. The most important achievement of this approach is the development of a set of signs ready to be used not on one map, but on a series of tactile maps depicting historic gardens in various garden design styles. These signs can be used to develop tactile maps of any parks, at different levels of detail. The repetition of signs on maps of gardens in different design styles additionally facilitates the understanding of the content of tactile maps.

Methodically tested readability of tactile signs makes the obtained results objective. The final signs set is readable and understandable by the target (diverse) audience. Understanding the meaning of signs and their legibility is repeatable, regardless of age, type of visual impairment or experience in working with tactile maps. This creates premises for a wide use of tactile maps designed in the proposed manner, as well as takes a step towards standardizing the characters used on maps.

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