

# The Importance of a Sensory-Motor Wayfinding System for Promoting Autonomy and Mobility on People with Low Vision Condition

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## ABSTRACT

Some evidences related to demography will change the way we design built environment, mainly hospitals. The world is facing a situation without precedents, so that soon there will be more elderly of extreme old age than ever before. With a continuous decline in death rates and rising life expectancy among them, reaching 80 years and even over 100. Living longer with a better life quality doesn't mean a healthier living, but a hospital care dependency related to health problems. We are facing a change of the demographic profile for which we must undertake a mentality readjustment in order to suit and give qualitative answer to these groups' life. With an increasing ageing population, the burden of age-related sensory impairment is expected to increase. There is a growing interest in the effects of the physical environment on the health and well being of the elderly and disabled population. The research is being held in an ophthalmological hospital, where all kinds of eye pathologies are treated, though presenting difficulties in color discrimination and perception, incapacity of reading at distance and interpreting complex pictograms. For a structured and effective research a participatory design methodology is considered to evaluate patient's low vision condition and working health professionals testimonials. Through observation, interviews and tests validating its results with groups of specialists. The final result will be the installation in this hospital of a sensory-motor wayfinding system (Percept Walk) reflecting the conclusion held in the research process.

**Keywords:** Percept Walk, low vision, wayfinding, kinesthetic perception, participatory design.

## INTRODUCTION

This paper is a on going research project – Percept Walk, developed at CIAUD – Research Centre of Architecture, Urbanism and Design at the Faculty of Architecture in Lisbon. The research has as final objective to promote an independent way for elderly people with low vision condition to act autonomously in hospital environments using a sensory-motor wayfinding system, combining a kinesthetic haptic perception system applied on the floor with an adjusted to low vision pathologies wayfinding system.

This PhD research project overlaps different research areas, using literature review and case study methodology, using relevant international case studies, and has an experimental phase developed in two Portuguese hospitals, using participatory design. A number of researchers have commented on the limited number of studies dealing with Ergonomics In Design, Usability & Special Populations I (2022)

person-environment fit in hospitals (Devlin & Arneill, 2003, p. 667). As main result, it is expected the developing of new tools and the creation of an Information Design model supported by a user-centred design process for an orientation system that, besides the most important act that is orientation, can also promote independency and, consequently, self esteem on people with visual impairment. It is also expected that, giving nurses and medical professionals more time to do their job and not having the need to help users, who cannot perceive and interpret the space, by showing at all time the destination required, their work will be more valuable for the institution where they work.

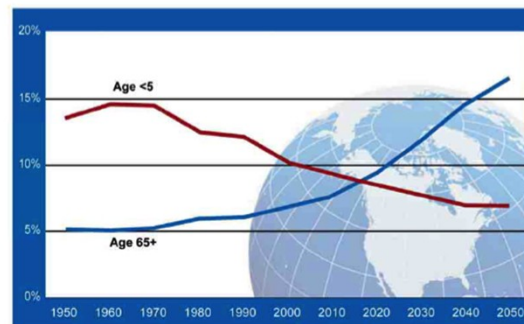
“Our senses are the instruments of communication that facilitate our relationship with the environment” (Meerwein et al., 2007, p. 13).

## IMPAIRMENTS AMONG ELDERLY PEOPLE

A new paradigm has significantly transformed the world’s demographic organization in the last century, in result of a rapid increase of an elder population, as reflex of the decline of birth rate and the increase of life hope. Today the elderly have a bigger longevity, reaching the old age later and with a better quality of life. But this better quality of life does not reflect possible problems related to health. Aging is related with the state of health and implicitly related with the general functioning diminishing (Kent & Butler 1988 in Fontaine, 2002, p. 55) and of common knowledge that these problems grow in a constant form (Birren & Shaie, 2006).

Figure 1 – World population prospects: The 2010 Review. United Nations. (WHO, 2010)

Young Children and Older People as a Percentage of Global Population: 1950-2050



Source: United Nations. *World Population Prospects: The 2010 Revision*. Available at: <http://esa.un.org/unpd/wpp>.

This major longevity due to the progress of medical science and social-economic conditions brought an apparent well being for a longer period of time. But reality shows that a large part of the older people present a major dependency, in general, related to health problems. This situation is part of the population that in result of aging have their visual capabilities declined (Mitchell, Hayes & Wang, 1997; Tielsch et al, 1995 in Gohar, 2009) with the gradual aging of the eye’s functioning, with changes in the retina and eye’s nervous system affecting acuity, accommodation, speed of adaptation to change and a variety of perceptual disabilities such as blurring, decrease spatial abilities, loss of colour discrimination etc. (Wijk et al., 1999; Wijk&Sivik, 1995 in Gohar, 2009). Most of these visual losses are related with low vision, in people over 60 years, and it provokes intensive medical care needs in hospital ophthalmology services. Most of the hospitals don’t dispose of a wayfinding system that reflects some of the limitations found in these pathologies, which in fact need an effective color contrast, a dimensionally adapted written information or even a haptic perception information for more efficiently promote readability and orientation.

### Perception in the elderly people

When walking, most of the elderly with low vision defend themselves from unbalance or falling by dragging their feet in order to feel the ground. By this defensive way of walking they can react when perceiving eventual irregularities on the ground. Falling is feared by them representing long time in hospital or at home in bed due to extended time bone recovery, a factor related with aging.

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Perceptions are a set of physiological and psychological mechanisms whose functions are to gather information in the environment or in their own organism (Lieury 1990 in Fontaine, 2002) and are polisensorial because they are product of an integration of diverse sensorial messages. We all use more than one perception to sense a determined space or an action. Perception is the awareness of more complex characteristics of the stimuli, the activation of the sensation cells and the interpretation of that information by calling on stored memory (Fisk, Rogers, Charness, Czaja, & Sharit, 2004, p. 13). However, limitations that are associated with perception, cognition and the control of movements increase in prevalence as one ages.

## Haptic system perception

Pallasmaa (2005) in his book “The eyes of the skin – architecture of the senses” underlines the importance of the tactile sense for our experience and understanding of the world, over the visual sense. Referring Ashley Montagu’s medical evidence on confirming the primacy of haptic realm he writes “touch is the parent of our eyes, ears, nose and mouth. It is the sense which became differentiated into the others, a fact that seems to be recognised in the age-old evaluation of touch as the mother of the senses” (Pallasmaa, 2005 p.11).

In both haptic and visual perception, the stimuli rely on material (texture, temperature, density) and space characteristics (form, place, orientation, length) (Hatwell, 2003 in Herssens & Heylighen, 2008). Information from movement output thus plays an important, and probably crucial, role in tactual recognition” (Millar 1994 in Herssens & Heylighen, 2008). Elderly walk in a defensive and secure mode, feeling one’s way by dragging their feet. This situation permits them feeling the floor, avoiding the unlevelled and/or irregularities of the ground. The introduction of a haptic system (on the floor) in a wayfinding system in hospital environment can act as a mean to lead people on finding the information required and so promote a better and more detachable information and thus, to add those with low vision condition to find their way. This can be referred as the practical intelligence (Vygotsky in Tijus, 2001, p. 25) where the-knowing-what-to-do is not expressed by language but by the action itself, and by Gibson’s (Gibson, 1986) affordances theory which, by feeling the haptic texture on the floor, people will know what they are meant to do.

The haptic system uses combined inputs from both the cutaneous and kinesthetic systems (Klatzky & Lederman, 2003, p. 148). The sensing modality of touch can be categorized into three main channels: kinesthetic describing our bodily perception when moving sensing the orientation and rotation of our muscles, joints and tendons; tactile stimuli are applied in our skin, when we are passive and a haptic sensation is produced during the exploration of an object (Loomis & Lederman 1984 in Pohl & Loke, 2012, p. 2). Touch is the parent of our eyes, ears, nose and mouth. It is the sense that becomes differentiated from the others, a fact that seems to be recognized in the age-old evaluated of touch as the “mother of the senses” (Pallasmaa, 2005, p. 2).

## Visual perception

The effects on aging in the visual system appears at 40 years on the optical structure and from de 60 years on the retinal structure (Fontaine, 2002, pp. 72–74) producing modifications in both optical structure and retinal system. In the optical structure, it affects the transmissivity and its accommodation capacity, translated into problems on objects distance perception, in depth, in sensibility to obfuscation and colors. This happens due to modifications in the four optical structures:

- cornea opacifies becoming thick and rigid provoking an augmenting of astigmatism and blurred vision;
- ocular muscles linked to the crystalline, atrophy provoking a decrease in the capability of eye accommodation, resulting in difficulty of seeing objects when near;
- crystalline (the lens that permits the projection of images on the retina) becomes rigid causing a diminishing in the accommodation capability, and yellows, modifying the light composition projected on the retina and sometimes becomes opaque, causing cataract in the elderly;
- posterior chamber, containing the vitreous body liquid, liquefies and has a tendency with aging to become clearer and gelatinous and the result is a augmentation to sensibility and obfuscation;

On the retinal system the receptor cells (cones responsible for seeing in colors and rods responsible for seeing in

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black and white) are located in the fovea (the central part of the macula) and suffer chemical alterations by lighting excitation which results in the generation of nervous influxes that reach the occipital areas of the brain through the optic nerve. With aging augments the probability of macula cells' degeneration resulting in loss of fine detail vision.

These effects on vision and also in hearing are general cognitive functioning sensorial deficits and of central nature, associated to neuronal deteriorations, as seen in some research works on elderly people aged over 60-70 years (Werner et al., 1990; Fozard, 1990 in Fontaine, 2002, p. 75), although other researchers don't see a significant association in this deficits (Horn, 1980; Schaie et al., 1964; Raz et al., 1990 in Fontaine, 2002, p. 75).

## Low vision pathologies

Few eyes that have survived 65 or more years of life are free from at least some slight sign of deterioration, degeneration, or past or present disease (Jackson & Wolffsohn, 2007, p. 78). Low vision could be defined as 'vision that, when corrected by optimal refractive correction, is not adequate for the patient's needs' (Jackson & Wolffsohn, 2007, p. 10), and also that it has to be seen as the attention to the retained residual visual and not the one that is lost.



Fig.2 – Low vision pathologies. Portuguese Vision Health National Program. Source: <http://dgsaude.min-saude.pt/visao/html/> [Accessed 2011/05/20]

The most prevalent etiologies in low vision are **AMD** (age-related macular degeneration) responsible for the majority of cases in severe loss of central vision, **cataract** symptoms include decreased in visual acuity, in color perception, in contrast sensitivity, glare disability and gradual onset of blurred vision in distance, **glaucoma** with either visual field (peripheral) loss and/or optic disk cupping, difficulty in functioning in dim light, decrease in contrast sensitivity, glare disability and decrease in dark/light adaptation, **diabetic retinopathy** characterized as a blurred vision (Jackson & Wolffsohn, 2007, pp. 77–92, Rosenberg & Sperazza, 2008). The elderly visual impaired are the group that optometric practitioners deal more with, and most of them deal well with the situation although a small minority has never accepted the situation and isolate themselves in their homes.

## Self-esteem and independence

Self-esteem refers to a person's sense of value and worth, a sense of competence and adequacy, a sense of self-satisfaction (Tuttle & Tuttle, 2004, p. 6). "*Self-esteem is the lived status of one's competence in dealing with the challenges of living in a worthy way over time*" (Mruk, 1999, in Tuttle & Tuttle, 2004, p. 6). Success in independent travel tasks, even at the beginning levels, can bring about an improved self-concept, a greater sense of independence, and improved motivation for other tasks, but the opposite may lead to an increase of dependency, isolation (Welsh, 1980, in Tuttle & Tuttle, 2004, p. 28). Self-esteem and self-satisfaction result from independence acting on the decision of doing things by his one and not relying or expecting from others to have that specific task done. Chapman (1978) describes the acquisition of independence as a gradual process of decision making, a act by itself and responsible (Tuttle & Tuttle, 2004, p. 59).

Information design oriented to this target group can act as a way of promoting this self-esteem and independence. By working with all users of a space through a participatory design process and a user space evaluation (main circulation axes, navigational signage and space lighting), all information obtained in both fields, will bring what is most important for showing the essentials for communicating a determined space. Although the research seeks the relation of patients and space, it proposes overall a simplification of the orientation information. Simplifying a wayfinding system in a determined space will without doubt improve its comprehension and promote self-esteem by

promoting independence to its users.

## **A SENSORY-MOTOR WAYFINDING SYSTEM**

The research project, Percept Walk, can be defined as the sensorial capacity that allows a human being of collecting the explicit information of the physical environment, in particular the spatial organization, in order to act in conformity, which in the present research is of visual and haptic touch order. Within the project different phases of sensorial evaluations (see methodology) will be held with low vision patients, users and medical staff.

The use of a sensory-motor wayfinding systems joining a correct colour use for legibility and readability of written information, associated with simplified pictograms, also applied in effective contrasts, and supported by a haptic system (foot touch) on the floor, may result in an effective way of displaying information in hospital environments. Older people with a low vision condition need a wayfinding system that can be seen by them at a relative small distance. The ability to detect and recognize objects in the visual environment varies considerably as a function of target size, contrast, and spatial orientation (Olzak & Thomas, 1985 in Schieber, 2006, p. 141). Numerous studies reveal a consistent pattern of age-related change in the CSF (contrast sensitivity function) collected under photopic conditions (foveal presentation at moderate to high luminance levels). Contrast sensitivity declines by approximately 0.3 log units across the later half of the adult life span (ibid., p.141).

The theme “color promotes wayfinding” has been largely studied and is still being studied by different authors (Arthur & Passini, 2002; Carpmann, Grant, & Simmons, 1984; D. Gibson, 2009; Helvacioğlu & Olguntürk, 2010; Katz, 2012; Mahnke, 1996; Meerwein et al., 2007; Mollerup, 2005; 2009; Moreira da Silva, 2013; Zingale, 2010). What is of real importance is that the colors and the system used are effective for those who use that specific building.

A wayfinding system, using effective colors, contrasting the written information with the background color, associated with a haptic touch texture on the ground, as a tactile physical help on defining and signalling the orientation information, will offer the visual impaired user access for reading the information at his most convenient distance. There is a acceptability by people for touching floor surfaces, via the shoes, on contrast of people being averse to touching certain objects in public spaces (Visell, Law, & Cooperstock, 2009, p. 149). The introduction of a sensorimotor task on the pavement does not imply an increased sense since it is implicitly engaged on normal walking (Visell et al., 2009, p. 150). Active touch, what is ordinarily called touching, is an exploratory sense and may be termed tactile scanning, by analogy with ocular scanning (J. J. Gibson, 1962, p. 477). Visual impaired people as all humans compensate for deficiencies or weaknesses in one sensory modality by relying on another sense, without necessary being aware of it (Krippendorff, 2006, p. 143). We use all our senses to perceive and use the environment. We do not use one specific sense to do it, but as normal vision people sight is the first sense used, leaving although other senses aware. When using a building, in particular a hospital, we don't have to adapt ourselves to this environment, but it is the environment that has to be adapted to us (Herssens & Heylighen, 2007). There is a need to rethink and adapt the functionality of a particular building to its users' needs or special needs. Those are inclusive design objectives, aiming at usability and comfort for as many people as possible regardless age, ability or circumstance (ibid.). Our ability to cope effectively with the environment begins with our capacity to process sensory input, although advancing adult aging brings with it systematic reductions in the efficiency of our sensory systems (Schieber, 2006, p. 129).

People are living longer, remaining more active into older age, and preferring to stay in their homes longer before feeling the need for “assisted living” arrangements. Aging brings with it changes in perception, cognition, and movements control (Fisk et al., 2004, p. 4). The ultimate science goal and the human factors' practice is to ensure that human-system and human-environment interactions will be safe, efficient, and effective (ibid., p.13). The ability to function independently is much related to our mental capabilities as to our physical capabilities (Huppert, 2003, p. 41).

## **METHODOLOGY**

The research is supported by a participatory design methodology evaluating through interviews and sensorial tests

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(visual and haptic). The visual tests will evaluate the visual acuity, color and contrasted color perception, legibility and readability in the different patients low vision pathologies; the haptic tests will measure the foot haptic perception to textures, and the independent mobility of patient's locomotion and dexterity.

The visual tests are supported by printed plates with different color contrasts, simplified pictograms and texts with different typographies and scales shown in different lighting conditions, while haptic tests are based on different shapes and thicknesses to evaluate the most perceived and interpreted within the different patient pathologies.

Through different phases of evaluation (see Fig.2) of the target group perceptions the research will seek for the necessary answers building efficient information for the design project. All the data acquired will permit to obtain some pre-conclusions of the research phase that will lead to the development of the design process of creating a pilot project for a specific part of this hospital. This area will be a lab of experiences and tests with patients and users to validate the pre-conclusions and recommendations obtained in the prior phases.

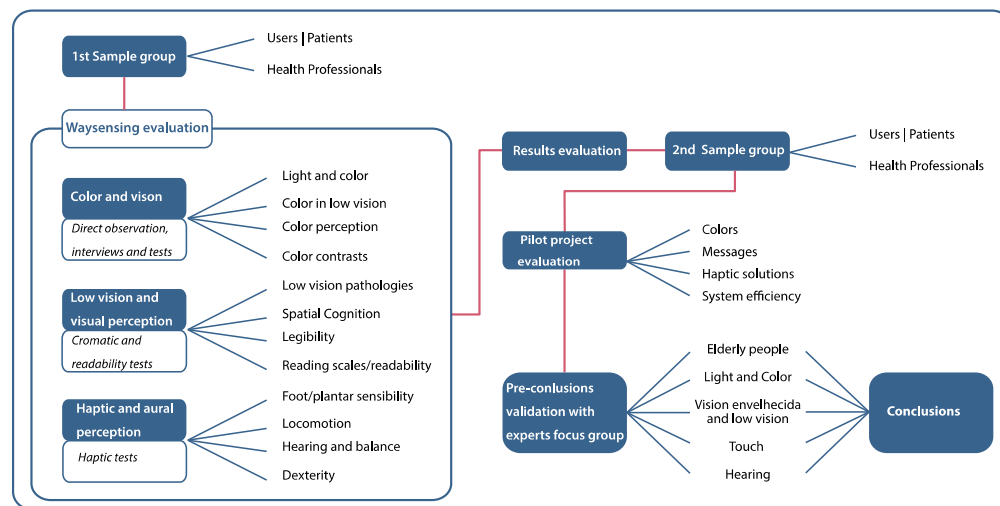


Fig. 2 – Waysensing: Research evaluation process

Within the different phases of the waysensing process the evaluation on the target group sensorial perceptions will seek for the necessary answers, building efficient information for the design project. The behavior of users and medical staff will be analyzed and evaluated in both areas, the intervened and the actual one, and compared in order to validate the wayfinding system proposed effectively responds in users' independent mobility and thus promoting self-esteem and confidence on a safe usage of the hospital.

## CASE STUDY

The first phase of the experimental research will be held in a public ophthalmology hospital (around 5.000 patients/month) offering a variety of services, such as consultations, exams, treatments and eye surgeries.

A general observation of the natural and artificial light conditions will permit to establish and parameterize optimal condition for interpreting the orientation information for all pathologies and minimize the effects of shades in some areas. Through direct observation of the patients and users usage of the building, the main axes of circulation and the most used areas will be evaluated so that the localization of the necessary information for an effective wayfinding/waysensing system will be implemented. The importance of the patient's sensorial evaluation is, in this particular case, visual and haptic touch oriented. But a research held in another environment with different special needs users may result in an approach to the evaluation of other senses but still aiming for the promotion of a safe, inclusive and structured usage of the space.

## CONCLUSIONS AND FUTURE WORK

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The Percept Walk sensory-motor wayfinding system represents a more sensorial involving way on the deconstruction of the built environment, in particular ophthalmology hospitals for people with low vision condition or other special needs. By promoting an independent mobility on these patients it will also promote self-confidence and self-esteem on them. Having patients and users acting by themselves in the building is expected and to leave more effective working time for doctors, auxiliary teams and nurses who actually spent a great deal of time showing and helping users to find their way around, are the research hypothesis expected to be achieved.

The Percept Walk system concept is perfectly applicable to situations with absence of light even if they are for normal vision people, for instance auditoriums or exhibition places. There is always information that can be conveyed through haptics, especially when visual noise is present.

The future work is the starting of the experimental phase in hospital, with the preparation of a specific area for interviewing, testing and defining the area for the pilot project installation and its implementation. Between the two phases of the sample groups' evaluation the design process for the pilot project will be defined and designed with the suitable means for the expected result of promoting mobility, independence and consequently self-esteem on patients and having medical staff with a more effective working time.

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