Haptic design research:

A blind sense of place

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1. Abstract

While architecture is experienced with all senses, the visual tends to receive most attention from designers. This paper focuses on the role of haptics, i.e. the sense of touch, in the built environment and reports on the development of haptic design parameters to support architects in paying more attention to the haptic implications of their design decisions. Haptic qualities and constraints in the built environment were identified with the help of people who are congenitally blind, as they are more attentive to non visual senses, and with professionals working with them. This paper summarizes and triangulates the results of these empirical studies and outlines the basis of the haptic design parameters derived from them. Following the classification of haptics into active, dynamic and passive touch, the built environment unfolds into surfaces that can act as “movement”, “guiding” and/or “rest” plane. Furthermore some techniques are suggested to check the haptic qualities of a design.

2. Introduction

Studies in architectural theory and design research have greatly multiplied in recent years. However relatively little research has been done on the multisensory experience of the architectural environment. Even if it is generally agreed that we experience the built environment with all senses (Rasmussen1964; Pallasmaa 2005a: V; 2005b; Campbell 2007), few architects bear the haptic, olfactory, gustatory and auditory sense in mind while designing. As Nigel Cross (1982) states, architects and other designers know, think and design very visually. Moreover vision is often quoted as the spatial sense par excellence (Foulke 1983) and it is said that our Western civilization is dominated by vision (Classen 1998:2; Pallasmaa 2005; Herssens, Heylighen 2007; Ryhl 2009; Passe 2009)

Nevertheless, if architects design with more attention to non visual senses, they are able to contribute to more inclusive environments. Indeed if an environment offers a range of sensory triggers, people with different sensory capacities are able to navigate and enjoy it. Rather than implementing as many sensory triggers as possible, the intention is to make buildings and spaces accessible and enjoyable for more people, in line with the objective of Universal Design.

Within this overall objective, the aim of our study is to develop haptic design parameters to support architects during design. In this study haptic design parameters are defined as variable characteristics (quantitative or qualitative) that can be decided upon by designers during the design process, and the value of which is a determinant of the haptic characteristics of the resulting design. To this end, we call in the perspective and experience of people who are born blind, as they have learned to be more attentive to the non-visual senses (Warren 1978; Hollins 1989; Herssens, Heylighen 2008; 2010). The first section defines haptic perception in relation to space/place and sets out the theoretical framework for this link. The next section zooms in on the methodology we used to identify haptic qualities and obstacles of the built environment, followed by the analysis of the data and the resulting design parameters. We conclude with suggestions for the assessment of haptic design parameters and the discussion adds directions for future work.

3. Background

The research of place and space

Ever since people have been dwelling, the meaning of space and place was one of the primary questions in life. In his book “Space and Place: The Perspective of Experience”, professor of geography Yi-Fu Tuan (1977:6) explores the meaning of both terms. “Space” is more abstract than “place”, but : “*space can become place if we get to know it better* ”. According to Tuan both ideas or words require each other for explanation. He points out that if we think of space as movement, then place is “pause” and this way each pause in movement will allow a space to become a place. Tuan’s approach is interesting as it explains the meaning of space and place with regard to movement.

Haptic perception involves connections between movement and touch (Millar 2005:250). Géza Revesz (1931) first introduced the term "haptics" and the origins of the word can be traced back to the Greek words *haptikos,* meaning "able to touch," and *haptesthai,* meaning “able to lay hold of” (Revesz 1950).

Research in experimental or developmental psychology, engineering or robotics used the term ‘haptics’ first for defining the active exploration of objects or environments through the body. Today haptics in its broadest sense encompasses the study of touch and the human interaction with the external environment through touch (Minogue, Jones 2006: 318; Herssens, Heylighen 2007).

In relation to the built environment, we argue, haptic perception involves active as well as dynamic and passive touch (Herssens, Heylighen, 2007, 2008a, 2008b, 2010). Whereas active (Heller 2000) and dynamic touch (Carello and Turvey 1996) require movement from the body itself, passive touch (Heller 2000) arises from movement in the environment.

Different from other senses, haptics enables us to modify and manipulate the world around us (McLaughlin et al. 2002): we cannot change our environment through hearing, seeing, smelling or tasting but we can through haptic body movements. Vice versa the sense of touch can leave its mark on the body itself; for example, the skin may be dried by the sun and roughened by the wind (Howes 2005:33). This strong interaction reveals the importance of touch for experiencing the built environment as through movement meaning can be given to a space.

On the surface

In developing haptic design parameters, we refer to the concepts of ecological psychology of James Jerome Gibson (1979). Although Gibson’s theory focused on visual perception in the first place, some principles turn out to be usable for haptic perception as well.

For example, one of Gibson’s most influential studies explored perception in relation to behavior and environment, in which the concept of affordances refers to the opportunities for action provided by an object or environment. Providing opportunities and choice in ways of use is one of the principles of Universal design, as is designing for simple and intuitive use (Connel et al. 1997).

Besides offering insights in environmental aspects, Gibson focused on human movements as an essential source of information in the ecological psychology of perception. Knowing that haptic perception requires movement, it is presumed that this theory can open up new perspectives.

A third connection refers to the representation of the world in terms of surfaces. Gibson (1979:13) points out that motion of things in the environment differs from motions of bodies in space: *“The terrestrial world is mostly made of surfaces, not of bodies in space. And these surfaces often flow or undergo stretching, squeezing, bending and breaking in ways of enormous mechanical complexity.”* As the haptic sense is a proximal sense (Millar 2006:28; Paterson 2007:128; Paterson 2009:1) and it receives information through proximal bodily experience (meaning the skin, muscles and joints), we argue that surfaces play a key role in the haptic qualities and obstacles of the environment. Haptic perception limits the acquisition of information to the immediate surrounding area that can be effectively tactually accessed. One major difference between visual and haptic discerning of space is its scale that can be accessed (Barber, Lederman 1988:99). Haptic exploration limits the vantage point, while visual access is expanded merely by turning one’s head (Amedeo, Speicher 1995:117).

4. Methodology

Three approaches

In order to identify haptic qualities and obstacles in the built environment, a qualitative research approach has been adopted, following the principles of grounded theory (Glaser, Strauss 1967). Interview material is considered as key material in this study. Moreover profound contact between participants and researchers is explored in familiar settings as according to Denzin, Lincoln (1994:7) "*qualitative researchers study things in their natural settings, atempting to make sense of, or to interpret, phenomena in terms of the meaning people bring to them"*. This approach fits in with the aim of Universal Design in which the experience and perspective of user/experts (Ostroff 2001:1.10) are applied to investigate the environment. Qualitative research is considered as an interdisciplinary field (Denzin, Lincoln 1994) in which theory and practice can interact. It opens up an interpretive way of analysing material and the more research methods are used, it is argued, the richer and higher valued the resulting material (Cohen, Manion 1986: 254). Therefore we chose to combine multiple methods: in-depth interviews, observations, photo-ethnography and focus interviews to collect data on haptic qualities and obstacles in the built environment.

First of all, in-depth interviews were conducted with 22 adults (7 women, 15 men) being born blind and living independently meaning alone or together with family but without professional support (Herssens, Heylighen 2008; 2010). The place of research was the adults' own home environment. From a theoretical point of view, "home" can be understood as a multidimensional concept (Bowlby *et al.* 1997; Wardaugh 1999; Somerville 1992; Mallett 2004). From an empirical point of view, it is for the participants the most familiar place offering safety and comfort; this was expected to encourage people to talk about the multisensory atmosphere in the built environment. On arrival participants were invited to participate in an open semi structured interview about their living environment and dwelling attitude. Afterwards, they were asked to give a guiding tour through their home environment.

Besides interviewing adults who are blind, we worked with children too, as it was hypothesized that children would react more spontaneously and are less encultured than adults. At an institute for the blind, children between the age of 3 and 13 years old living at the boarding school were observed during five months and four of them (3 girls, 1 boy) were asked to participate in a photo-ethnographic study (Herssens, Heylighen 2009). All photographers are congenitally blind and were invited to take pictures of places in and around their boarding school.

While these two methods both called in the experience and perspective of people who are congenitally blind themselves, the third method tried to learn from the experiences of people who worked for years with congenitally blind people. We conducted focus group interviews with two groups of about eleven people trained as remedial educationalist, physiotherapist, occupational therapist, socio-cultural worker or educator (18 women and 5 men). The focus interviews were designed within a semi structured format. People were interviewed in a familiar environment at their workplace. Each interview started with a brainstorm exercise. All participants were asked to write down what came up in their mind when thinking about "touch". This action resulted in a discussion triggering the first questions.

Analysis

All data were cross-examined with the help of triangulation, a mixed-method strategy (Parker, Tritter 2006) used in social sciences, to answer the same key question: what are haptic qualities and constraints in the built environment? Flick (1998: 230) points out that triangulation " *is not a tool or a strategy of validation, but an alternative to validation."* Similarly Wolcott (1999: 220) suggest that it is "*but a reminder of the need to corroborate findings".*

The in-depth interviews were transcribed and the first coding was started using a list of key words resulting from our theoretical literature review. After a following go through, citations referring to haptic qualities and haptic constraints were selected and the analysis was continued by making a division between material and spatial characteristics. The following coding procedure did use data based key words, referred to by the participants. Gradually the division between active, dynamic and passive touch became clear and could be linked to respectively orientation, direction and atmosphere. The photo-ethnographic study was giving unique insights in the role of haptics in the built environment by images, the photographers' actions, their reflections on their act of photographing, and their talk about spatial experience. The pictures referred to different multisensory experiences, as well as movements. Like haptic perception itself, their act of photographing followed a sequential approach.

The focus group interviews were contemplating the insights of educators who were representing a mixture of daily impressions and professional information. Whereas the in-depth interviews and photo-ethnographic study

reported on experiences of users themselves, the focus interviews were based on the perception of people working with congenitally blind which sometimes results in different opinions as educators give priority to orientation while users inform on passive touch as well.
The haptic design parameters resulted out of key terms found throughout the different empirical research studies; the variables for the parameters are based on theoretical as well as empirical results.

5. Results

This triangulation analysis enabled us to identify haptic qualities and constraints in the built environment. Although all interviews revealed the lack of vocabulary to talk about haptics, most results were confirmed throughout the three different approaches. For example, it became clear that furniture is as important as architecture itself and that both are perceived as a whole in haptic perception. Material characteristics can be landmarks themselves. Furthermore the data suggested the classification of landmarks, paths, nodes, edges, boundaries, once described in a visual context by Kevin Lynch (1960), to be applicable to haptics as well. Like a tower can be a visual landmark, a difference in a floor texture on a city square can be a haptic landmark. Moreover participants often referred to environments explaining paths, nodes, edges, boundaries and landmarks. One of the educators points out that: "*The dare for movement is the start for every learning event*".
The data strongly suggest that haptic qualities and obstacles in the built environment relate to surfaces. For example, when we walk over a bridge we feel the upper surface of the floor while placing our foot on the bridge, the surface of the handrail while passing our hand over the handrail. Not the volume of the floor is felt, nor the points or dots that compose this surface as their scale is too small, but its material and spatial characteristics. A line is never felt as a line the way it is seen by a seeing person, but as a meeting between two surfaces. This understanding of haptic perception leads us to propose a specific design approach: designing by using and compiling surfaces.

Environmental-Perceptual classification

Our data indicate that the experience of the surface depends on its use. Architects can design an environment that supports orientation as well as creates an atmosphere, orchestrating both body movements and feelings. With the theory of affordances in mind, surfaces can suggest a seat, a floor, a ceiling, a place to rest,… Different functions ask for appropriate haptic qualities which designers can determine. The more we actively touch, the more important it is that the haptic stimuli inform us on orientation, while the atmosphere is experienced more passively. Dynamic touch on the other hand forms the transition between orientation and atmosphere.

Besides the way in which we touch, it is important for designers to keep in mind which body part will touch or be touched, as body parts can differ in haptic reaction and are characterized by more or less sensitivity. For example, stimuli felt by the feet, back, arms and shoulders differ from those felt by the hand or other body parts. For touch the most sensitive regions are the lips and fingertips, whereas the back, shoulders, legs and arms yield much higher thresholds (Goldstein 2010). This way, our hands are more sensitive than our feet which means that surfaces supporting our hands ask for different texture than surfaces meant to guide our feet. Consequently we propose to divide the parameters into varying surfaces relative to the body. The classification is not strictly environmental meaning that it does not just rely on architectural characteristics; rather it reveals an environmental-perceptual classification as it is based on how people perceive touch in the built environment.

Moving/ guiding / resting

We propose to divide the surfaces architects design into three categories: "movement plane", "guiding plane" and "rest plane".

The more we focus on orientation, functionality and safety, the more important it is to include parameters referring to active touch, aiming at an environment that gives priority to effective, rational and efficient movement. As a result we could state that taking haptic conditions in mind, functional oriented design asks for surfaces that we could name as "movement plane". For example, a ground floor in the underground, the steps of a staircase or a door of a public entrance.

On the other hand if atmosphere is more important, designers are asked to look at the characteristics of passive touch to create a more holistic experience. These parameters will support designers to create a "rest plane" , a surface on which people can sit, sleep, relax, lean, hang,…It is a plane as part of a design in which the focus lies on the body in rest, for example the wall of a hallway we lean against. This way the “rest plane” can be part of a ”movement plane” or a “guiding plane”.

Dynamic touch for its part depends on active as well as passive characteristics in that it involves touching the environment by means of an object. In this situation a “guiding plane” supports active and dynamic touch in the first place, a plane that literally can guide and support someone but where experience is important as well. This way the guiding plane can form a movement plane as well. The guiding plane supports and coordinates active, dynamic as well as passive touch as it aims at giving its users insight into the structure of the environment.

Guiding planes are part of the passage way and are placed parallel or perpendicular to the run or moving line. A handrail, for example, can be actively touched but gives information about the wall or construction on which it is fixed as well. It becomes clear that a movement plane can be a guiding plane as well as a rest plane.

Figure 1: sketch fountain on square (sketch by Iwert Bernakiewicz)

Figure 1 illustrates this complexity: it shows a fountain on a city square, a tourist attraction that besides its ornamental function structures the layout of the square and suggests a place for rest. Accordingly the fountain is composed out of different planes and some people sit or lean on its borders while others focus on the border planes to orientate. The floor of the square itself can be named as a movement plane, while the fountain borders are guiding planes or rest planes or can even be

Figure 2: sketch fountain on square, experiencing planes (sketch by Iwert Bernakiewicz)

movement planes when children are moving from one side to the other. It is assumed that the more a designer can create a successful movement plane that offers dynamic and passive characteristics as well, the richer the actual experience (Fig.2).

Haptic design parameters

The haptic design parameters are described by material characteristics and spatial characteristics (Fig. 3), and the variables are differentiating between foot and hand, dependent on the regions of sensitivity mentioned before.

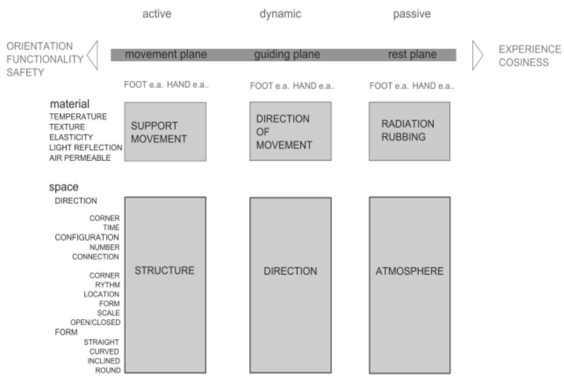

Figure 3: Framework parameters

Material characteristics

Materials give an identity to the surfaces through their temperature, texture, density, permeability, light reflection and elasticity. These constitute the different material parameters.

Temperature is traced back to the coefficient of conductivity (for example, steel feels much colder than wood) and the radiation of a material.

Unlike what one might assume, light experience is very important for haptic experience. Light can be haptically experienced through temperature rise. However, light is more passively perceived by the sense of touch, consequently we refer to the temperature parameter for the variables as light is passively experienced through fluctuation in temperature. Actively or dynamically light can be perceived as an orientation point, but this happens less frequently.

Besides light, materials can also reflect or let through air. The latter is one of the most typical experiences for the sense of touch. Air that caresses our skin informs us about the structure of the environment. Materials can breath as well. This difference can be felt on a sunny afternoon when you are nestling yourself in your garden on a garden chair made of textile. While this textile material breathes the air of your body, a rubber mat will not and makes you sweat. Besides the material itself, the configuration of the surfaces will contribute to air experience which will be discussed later.

The texture of a material gives direction, reflects light and defines the way a material is felt. To support active touch, movement will be encouraged by a rough texture for the feet, while the hands and other body parts ask for smooth surfaces. When relaxing, on the other hand, the body prefers smooth textures for hands as well as feet. For example, rough stones are excellent for staircases but can be best avoided for walls that are regularly touched like movement planes.

Elasticity of a material is the extent to which a material practices a counterforce or is transformed under external forces. A material is considered elastic if it returns to its original form when no forces are performed. If active touch is priority, like in public buildings, preference is given to materials with no elasticity. The judo mat in the boarding school was felt as a very pleasurable material on the playground. In a public building on the other hand, it is better not to use a rubber floor. Although it does feel nice as it is soft, it is not practical at all as people risk to twist their ankle. An ideal dynamic guiding plane on the other hand is for example a grass surface next to a hard surface because it forms a guiding plane next to the run line.

Spatial characteristics

Spatial characteristics consider the way in which surfaces take part in the larger built environment. We consider three spatial characteristics: the direction in which the surfaces are put, the form of the surfaces, and the configuration in which the surfaces are composed.

The direction sets out the way in which the surfaces are placed in relation to the user and his/her body and body movement. For active touch preference is given to orthogonal surfaces, whereas a walk in the park asks rather for different options; even in the absence of sight choices contribute to the experience of the environment.

Some surfaces are moving or can move. Therefore the time in relation to the body and the referring surface is important. For example, in an airport speed is important and surfaces that support speed or that can move in line with the body are therefore favored, while at some places of pilgrimage, opening a door is part of a ritual that asks time and so it gives time to reflect.

Figure 4: “backbone wall” Hazelwood School for the Blind, Glasgow (U.K.) Gordon Murray + Alan Dunlop architects (picture by Jasmien Herssens)

Every surface can be placed or built following a certain angle in relation to the user’s body. This results into a corner that has influence on the experience and orientation. For movement planes, the wall surfaces are best placed at 90° or more while the floor has an angle of 0° or less than 3°. The same counts for guiding planes as this way it is possible to orientate yourself in space. For example, in the Hazelwood School for the blind in Glasgow (U.K) (Fig.4), the architects Gordon Murray and Alan Dunlop designed a “backbone wall” in the middle of the school that has different functions: first of all, it is a cupboard for the children’s coats, canes and briefcases and the teachers working material: secondly, it creates a transit zone between the passage way and the class rooms; and finally, it helps the children with visual impairments to orientate themselves as the wall is not orthogonally structured but twists through the building by making blunt angles with its surfaces. This way the “backbone wall” kinetically draws a line through the building.

Configuration highlights the number of surfaces that contribute as well as the way in which these surfaces are connected. The connections of surfaces form corners that inform the user on orientation. It is comparable to what we described as a corner in relation to direction, but differs in this way that it focuses more on the meaning of the corner in relation to the spatial form. Surfaces can appear in a rhythm which can stimulate movement. Surfaces can create a space and consequently this space will have a form. Moreover, in architecture, configuration mostly depends on scale. Architecture can be experienced on a micro-, meso- and macro-scale but, as elaborated, the sense of touch is proximal and will focus mostly on micro-scale as we perceive sequentially, step-by-step. The more the designer wants to integrate the passive haptic experience, the more attention needs to be given to micro-details as well. The plane itself can follow a straight line, a curve or it can be inclined. Different forms support the experience and orientation.

The parameters are meant to assist designers in designing environments with better haptic qualities. Parameters related to movement planes focus on the structure and try to support orientation and balance in movement, while parameters related to guiding planes inform on the direction of the surfaces in the first place. Parameters for the rest plane on the other hand give a description on the materials concerning radiation and rubbing of the skin and spatial characteristics creating an atmosphere.

A designer has the freedom to choose which parameters s/he applies and to accept the challenge to implement these parameters towards a well-balanced environment. The parameters are defined in such a way that they can be consulted and assessed over at any time in the design process. This assessment relies on well known spatial design practices in architecture and focuses on accentuating and clarifying the purpose of an environment. Assessing to what extent haptic orientation is fulfilled or active touch is included, designers are advised to check whether the space to move is conveniently arranged. This can be done by drawing the inverted space (Fig.5), meaning that the places where people move through are drawn instead of the designed surroundings. This way structure will become clear. Dynamic perception on the other hand can be checked by drawing the run lines (Fig.5) onto the plans. If run lines are supported by architectural elements, especially on decision points, dynamic touch is probably well supported. Passive touch is more difficult to represent as it is caused by movement in the environment. Nevertheless designers can encircle the fields (Fig.5) meant to be rest places and check whether these are not diagonally crossed by passage ways.

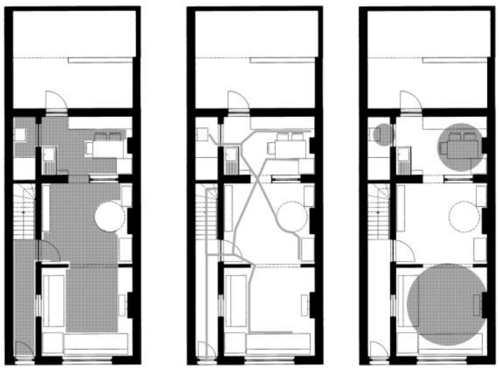

Figure 5: plan 1: inverted space| plan 2: run lines | plan 3 fields rest place

6. Discussion

Analysing the experience and perspective of congenitally blind revealed that we haptically perceive the environment relying on different surfaces affording and supporting different human actions. The more important active touch becomes, the more a designer needs to take into account the parameters of a movement plane while designing. If the atmosphere is most important, parameters of the rest plane can inspire the designer the most.

Interestingly, this approach gives the architect the freedom to stress what s/he finds the most important aspect of the design. Based on the characteristics of haptic perception, this study laid the foundations for haptic design parameters defined as limits in between which architects can choose to define the appropriate experience. Architecture creates opportunities in perception, experiencing, meeting, dwelling and designers will have to realize their major role in the process of creation. As we write, the proposed haptic design parameters are being tested with professional architects. Further research may reveal more details on different parameters. Moreover a longer term evaluation of these parameters in the design process would help to refine their representation as well as their content.

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Bibliography

Amedeo, Douglas, and Kate Speicher. "Essential Environmental and Spatial concerns for the congenitally visually impaired." Journal of Planning Education and Research 14 (1995): pp. 113-122.

Barber, P. O., and S. J. Lederman. "Encoding direction in manipulatory space." Journal of Visual Impairment and Blindness 82 (1988): 99-106. In Amedeo, Douglas, and Kate Speicher. "Essential Environmental and Spatial concerns for the congenitally visually impaired." Journal of Planning Education and Research 14 (1995): pp. 117.

Bowlby S, Gregory S, McKie L. "Doing home." Women's Studies International Forum 3 (1997): pp. 343-350.

Campbell, Robert. "Experiencing architecture with seven senses, not one." Architectural Record 195.11 (2007): pp. 65-66.

Classen, Constance (ed.). The color of angels. New York: Routledge, 1998.

Cohen, Louis, Manion, Lawrence, and Keith R. B. Morrison. Research methods in education. Oxon: Routledge, 1986.

Connel, Betty, Rose, Jones, M., Mace, Ron, Mueller, James L, Mullick, Abir, and Eileen. Ostroff. The Principles of Universal Design. Raleigh: NC State University, CUD, 1997.

Cross, Nigel. "Designerly ways of knowing." Design Studies 3.4 (1982): pp. 221-227.

Denzin, Norman K., and Yvonna S. Lincoln. The handbook of qualitative research. Thousand Oaks [u.a.]: Sage, 1994.

Denzin, Norman K., and Lincoln Yvonna S. (ed.). Collecting and interpreting qualitative materials. Thousand Oaks: Sage publication, 2003.

Foulke, Emerson. 1983: Spatial ability and the limitations of perceptual systems. In Pick, H.L. and Acredolo, L., editors, Spatial orientation: theory, research and application, New York: Plenum Press. pp 125-141

Flick, U. 1998. An introduction to qualitative research: Theory, method and applications. London: Sage. In Denzin, Norman K., and Lincoln Yvonna S. (ed.). Collecting and interpreting qualitative materials. Thousand Oaks: Sage publication, 2003. p. 8

Gibson, James Jerome. The Ecological Approach to Visual Perception. Boston: Houghton Mifflin, 1979.

Glaser, Barney G., and A.L. Strauss. The Discovery of Grounded Theory. Chicago: Aldine Publishing Company, 1967.

Goldstein, E. Bruce. The Encyclopedia of perception. : SAGE Publications, Inc, 2010.

Heller, Morton A. Touch, representation, and blindness. Debates in psychology. Oxford [u.a.]: Oxford Univ. Press, 2000.

Herssens, Jasmien, and Ann Heylighen. "Haptic architecture becomes architectural hap". Annual Congress of the Nordic Ergonomic Society (NES). Lÿsekil, Sweden: NES, 2007.

Herssens, Jasmien, and Heylighen Ann. "Designing for more senses", In Clarkson, John (Ed.), Patrick Langdon,. (Ed.), Joy Goodman-Deane. (Ed.), andPeter Robinson (Ed.), Proceedings of the 4th Cambridge Workshop on Universal Access and Assistive Technology.. Cambridge: University of Cambridge (U.K.), (2008a), pp. 101-105

Herssens, Jasmien, and Ann Heylighen. "Haptics and Vision in Architecture", In Lucas, Raymond (Ed.), Gordon Mair. (Ed.), Sensory Urbanism Proceedings 2008. Edinburgh: The Flâneur press, (2008b), pp. 102-112

Herssens, Jasmien, and Ann Heylighen. "A lens into the haptic world", Proceedings of Include 2009. London: Helen Hamlyn Research Center, 2009.

Herssens, Jasmien, and Ann Heylighen. "Blind Body Language, In Clarkson, John (Ed.), Patrick, Langdon (Ed.), and Peter Robinson, P. (Ed.), Proceedings of the

5th Cambridge Workshop on Universal Access and Assistive Technology. Cambridge: University of Cambridge (U.K.), (2010), pp. 109-118

Hollins, Mark. Understanding Blindness. Hillsdale/N.J. : Erlbaum, 1989.

Howes, David. "Skinscapes." The Book of Touch. Constance Classen. (ed.) : Berg Publishers, 2005. pp.27-40.

Grünwald, Martin, and John Matthias. "German pioneers of research into human haptic perception." Ed. Martin Grunwald. Springer eBook Collection, Biomedical and Life Sciences [Dig. Serial], Springer-11642 [Dig. Serial]. Basel: Birkhäuser Basel, 2008. pp.15-39.

Lynch, Kevin. The image of the city. Publication of the Joint Center for Urban Studies. Cambridge, Mass.: MIT PRESS, 1960.

Millar, Susanna. "Network models for haptic perception." Infant Behavior & Development 28 (2005): pp. 250–265.

Millar, Susanna. "Processing Spatial information from Touch and Movement." Touch and Blindness. Ed. Morton Heller, and Ballesteros, Soledad. New Jersey: Lawrence Erlbaum Associates, 2006. pp. 25-49.

Mace, Ron. A Perspective on Universal Design, Excerpt of a presentation made by Ronald L. Mace, FAIA, at “Designing for the 21st Century: An International Conference on Universal Design,” New York: Hofstra University, Hempstead. (1998). http://www.design.ncsu.edu/cud/about_us/usronmacespeech.htm on March 4th 2010

Mallett, S. "Understanding home." The Sociological Review 1 (2004): pp. 62-83.

McLaughlin, Margaret, Hespanha, João Pedro, and Gaurav S. Sukhatme. Touch in virtual environments. New York: Prentice Hall, 2002. In Minogue, James, and M. Gail Jones. "Haptics in Education." Review of Educational Research 76.3 (2006): pp. 317–348.

Minogue, James, and M. Gail Jones. "Haptics in Education." Review of Educational Research 76.3 (2006): pp. 317–348.

Ostroff, Elaine. "Universal Design." Universal Design Handbook. Ed. Preiser Wolfgang F.E.; Ostroff Elaine. New York: Mc Graw Hill Professional, 2001. pp. 1.3-1.12.

Pallasmaa, Juhani. "Architecture and the Human Condition." P.V In Another Eyesight, Multi-Sensory Design in Context. Ed. Julia Ionides, and Howell, Peter. Ludlow (U.K.): The Dog Rose Trust, 2005a. p. 411.

Pallasmaa, Juhani. Encounters. Ed. Peter MacKeith. Helsinki: Rakennustieto Oy (Building Information Ltd), 2005b.

Parker, Andrew, and J Tritter. "Focus group method and methodology." International Journal of Research & Method in Education 29.1 (2006): pp. 23-37.

Passe, Ulrike. "Designing Sensual Spaces." Design Principles and Practices 3.5 (2009): pp. 31-46.

Paterson, Mark. "The Senses of Touch." Oxford/New York: Berg, 2007.

Paterson, Mark. "The human touch." The Philosophers' Magazine .45 (2009).

Rasmussen, Steen Eiler. Experiencing Architecture. Cambridge, Mass: MIT Press, 1964 (2001).

Révész, Geza. Uber die Natur der optischen und haptischen Formwahrnemung. Amsterdam: Koninklijke Academie voor Wetenschap, 1931. In Revesz, Géza. (1950). *The psychology and art of the blind.* London: Longmans Green. p. 332.

Révész, Geza. "Blindenpsychologie." Het persoonlijke en sociale leven van de blinden. Ed. Geza Révész, and Zeeman, W.P.C., (ea). Leiden: H.E.Stenfert Kroese N.V., 1955. pp. 20-91.

Ryhl, Camilla. "Architecture for the senses." In Vavik, Tom. Inclusive Buildings, Products and services. Trondheim: Tapir Academic Press, 2009. p.269.

Somerville, Peter. "Homelessness and the Meaning of Home." International Journal of Urban and Regional Research 4 (1992): pp. 529–539.

Tuan, Yi-Fu. Space and Place. Minneapolis, London: University of Minnesota Press, 1977.

Wardhaugh, Julia. "The Unaccommodated Woman." Sociological Review 1 (1999): pp. 91–109.

Warren, David H. "Perception by the blind." Handbook of perception. Ed. Carterette Edward C ; Friedman Morton P. Vol. 10. New York: Academic Press, 1978.

Wolcott, Harry F. Ethnography. Oxford: Altamira Press, 1999.