The Innovation Potential of Sensory Augmentation for Public Space

Michel van Dartel
AVANS University of Applied Sciences
Breda, the Netherlands
mf.vandartel@avans.nl

Alwin de Rooij
Tilburg University
Tilburg, the Netherlands
alwinderooij@tilburguniversity.edu

Abstract

Potential for the improvement of public space through technology is often sought in telephone applications. However, public space exists by grace of physical interaction between people and their environment, whereas smartphones often get in the way of such interaction. In contrast, Sensory Augmentation takes physical interaction as a starting point for applications. In this paper, we therefore explore the innovation potential of Sensory Augmentation for the improvement of public space. This was done by organizing brainstorm sessions aimed to yield design concepts for the application of sensory augmentation in public space. These brainstorms brought together experts in Sensory Augmentation with various stakeholders and resulted in 34 unique design concepts that addressed social interaction, play, health, navigation, and art, in public space. These concepts, for example, included a tool for the management of private space using a personal distance-to-vibration mapping, a sense for physiological changes that are indicative of hunger, and a proposal to improve the safety of 'smartphone Zombies'. On the basis of our analysis of the 34 concepts, we conclude that Sensory Augmentation holds a broad potential to improve public space. As such, our research provides a first look into this innovation potential and may guide further research on it.

Keywords

Sensory Augmentation; Public Space; Artistic Research; Interface Design; Cognitive Science; Applications

Introduction

Sensory Augmentation (SA) applies perception theory that revolves around the idea that people perceive the world on the basis of correlations between their physical actions and the changing sensory input that results from those actions. [1] Based on this principle, also non-human sensor data can be translated into signals that are compatible with the human senses, in order to increase our ability to understand the world beyond what is "naturally" possible. [2] Interfaces that enable such translations have led to groundbreaking applications in the domain of health. For example, SA applications are being developed for people with impairments of the vestibular system that translate orientation into sound or convert image into stimulation of the tongue, providing a new sense of balance. [3] Another example, *The Enactive Torch*, is a flashlight-like box that translates the signal from a remote sensor into vibration of the box [4]. Moving this 'torch' offers the experience of 'seeing with your hand', which has been shown particularly useful for people with visual impairments. Despite successful health applications, the innovation potential of SA for other domains has barely been explored.

Public space design, the design domain that focusses on the development of places that are accessible and open to people, may provide such an application domain. Public spaces are continuously (re)developed in response to many different and changing challenges; from improving our sense of security to encouraging young people to exercise. While many of these challenges are nowadays addressed using smartphone applications, these devices have a difficult relationship with the core value of public spaces; the facilitation of physical interaction between people and their environment. In contrast to most software applications running on smartphones, physical interaction between people and their environment is the starting point for the design of SA applications. As such interaction is abundant within it, it seems that a wide range of possible applications is conceivable in the domain of public space design especially. This leads us to take a first look at the research question: *What is the innovation potential of Sensory Augmentation for the design of public space?*

To explore this research question, we have conducted a first inventory of potential applications as part of an ongoing collaboration between four partners: a specialist in IT applications for public spaces, a university of applied sciences and a research university that conduct collaborative practical and scientific research into SA, and a cultural organization specialized in interdisciplinary approaches to production and presentation.

Method

On July 4, 2018, an *interdisciplinary* group of *experts* and *stakeholders* was brought together at V2_ Lab for the Unstable Media, Rotterdam, NL, to explore the innovation potential of SA for the design of public space.

Interdisciplinary approach

Previous research has shown that exploration of the innovation potential of SA can benefit specifically from collaboration in interdisciplinary groups that include artists and scientists. [5, 6] This is because "creative research practices

emphasize the role of personal or subjective experiences", whereas "in the sciences … the subjectivity that accompanies experience is usually seen as an undesired variable that is to be controlled rather than enhanced" to obtain generalizable knowledge [7], p. 90. Knowledge obtained through these different methods can complement each other, providing a broader basis from which to develop creative and innovative ideas. [6] Participants for the present study were selected on the basis of these assumptions.

Participants

Experts. Each partner in the ongoing research was represented by one lead researcher whom together invited four experts on the topic of SA to participate in the workshop. Just as the lead researchers, these experts all had previous experience in the application of SA.

Stakeholders. Collaboratively, the experts identified stakeholders in several public space design challenges. These included an academic specializing in urbanism, a municipality policy developer, an artist duo specializing in interactive public artworks and a company developing interactive systems for play in public space.

Format

An introduction to the theory and practice of SA and its innovation potential by two lead researchers preceded a sequence of five parallel brainstorming sessions on specific challenges within the domain of public space. Each parallel session lasted one hour, and consisted of three groups with randomly assigned experts and stake holders. The challenges selected were based on the backgrounds of the experts and invited concepts that would facilitate or stimulate innovative forms of 1) play, 2) social interaction, 3) health, 4) navigation, and 5) art - within public space and incorporating the principle of SA. Each challenge was introduced by an expert at the start of each brainstorm, including the demonstration of an application relevant to the challenge and used as a starting point for the brainstorm. The brainstorms were moderated by two of the four lead researchers, who gave brief impulses in each of the five parallel discussions to steer the discussion towards design concepts for the application of SA in response to the challenge. Each group was urged to deliver at least one design concept at the end of each brainstorm; the maximum number of concepts was undefined. The resulting concepts were subsequently hung from several washing lines, after which they were presented and discussed in plenary. After the brainstorms, an evaluation of the concepts took place in which each participant was provided with five sticky notes; each note representing one point to award to (stick on) the design concepts that they felt held the largest innovation potential for SA in public space.

Data processing

For the analysis, redundant concepts were removed from the sample (n = 7). For example, if a concept using the same SA application to support tennis training and another was to us it for soccer training, this would be counted as redundant. This enabled a first look at the overall innovation potential of SA in public space. Consensual assessment was used by the two lead researchers to develop a hierarchy of design concepts. That is, concepts were grouped into primary and secondary application domains (e.g., if a primary domain is "art" a secondary domain could be "narrative"). This allowed further analysis to pinpoint where (in what sub-application domains) SA may have a particularly strong potential for innovation. Moreover, consensual assessment was used to check what concepts adhered to SA principles. This was used to support the validity of the results. Finally, concepts that were awarded more than three points by the experts and stakeholders were classified as having "potential for innovation"; concepts awarded more than zero but less than three were classified as having "possible potential for innovation"; whereas concepts awarded with zero points were classified as currently having "no potential for innovation". This categorization provides further specification of what potential for innovation SA holds for these application domains.

Reporting and documentation

Notes of the presentations and discussions were taken by a dedicated reporter (Figure 1) and formed the basis for a written report. [8] Photo-documentation was made of all the resulting design concepts, including the points that were awarded to them by the participants.

Figure 1. The reporter takes notes of a brainstorm. ©Kris Vleugels.

Results

The workshop yielded 34 unique design concepts for the application of SA for public space. (Figure 2) The concepts could be grouped into five primary application domains: 1) play (n = 6), 2) social interaction (n = 3), 3) health (n = 7), 4) navigation (n = 10), and 5) art (n = 8).

Primary and secondary application domains

Within each primary application domain, more specific secondary application domains could be identified, suggesting

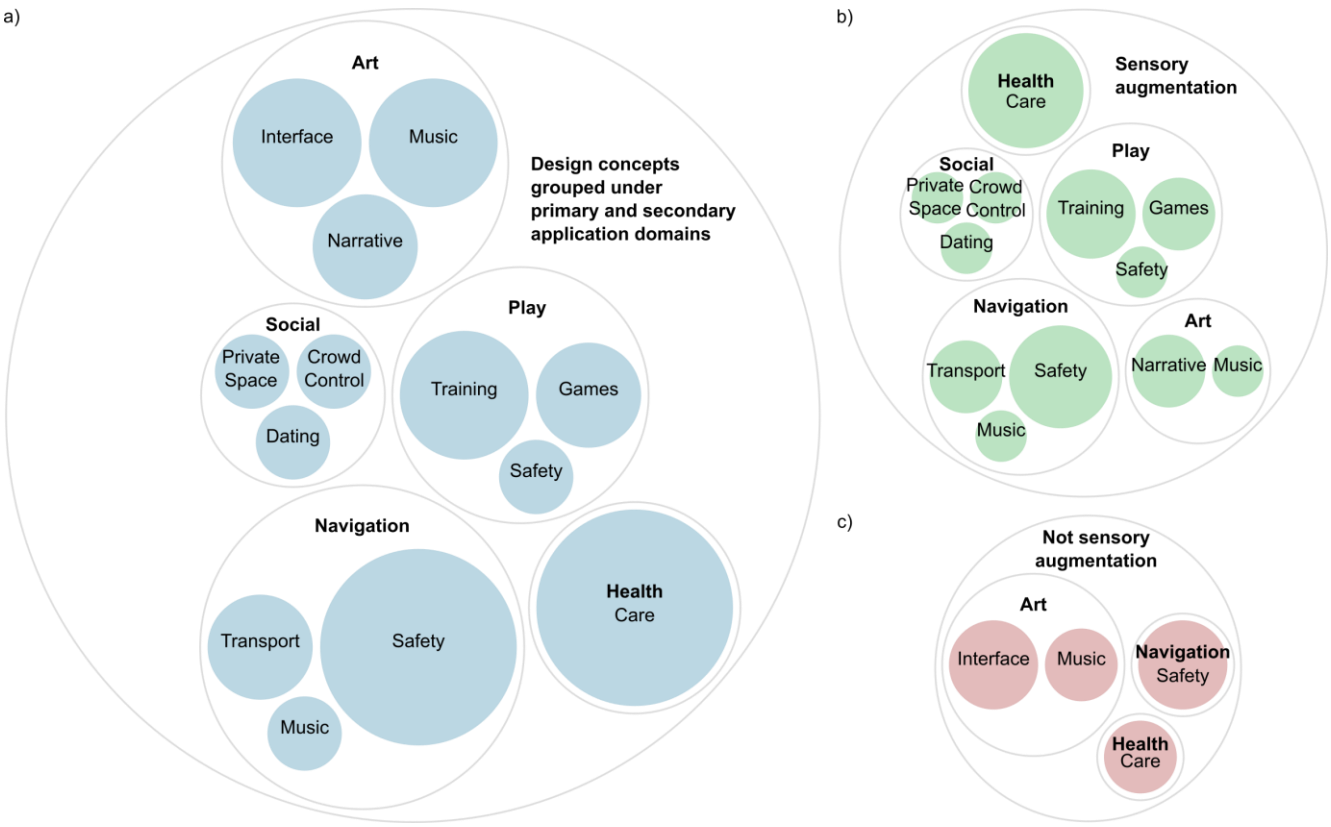

Figure 2. Visualisation of the amount of unique design concepts a) organised by their primary (bold) and secondary application domains, which b) incorporated SA principles, or c) did not incorporate SA principles.

a broad range of application domains that can be innovated on the basis of SA principles.

Design concepts for *play* indicated a potential to innovate training (n = 3), games (n = 2), and safety (n = 1). These included augmented sports training, e.g., by using a movement-to-tactile mapping to help learn the optimal movements needed to kick a ball into an intended direction, and augmented game play, e.g., by equipping soccer players with a 360° movement sense via a Doppler-to-sound mapping so that members of an opposite team could be sensed from all directions. All concepts for *play* incorporated SA principles.

Design concepts for *social interaction* indicated a potential to innovate the management of private space (n = 1), crowd control (n = 1), and dating (n = 1). These included augmentation of sensing private space in 360° (Figure 3a) by using a distance-to-vibration mapping that indicates when someone is within your private space range (which could be made dependent on a user's orientation relative to other people), augmented crowd control by using a distance-to-vibration mapping to choreograph movements within large masses, and augmented sensing of potential partners by a physiology-to-magnetic pull mapping that generates an actual physical pull depending on physiological measures of attraction. All concepts for *social interaction* incorporated SA principles.

Design concepts for *health* all related directly to potential innovations in health care (n = 7). These included using augmented posture sensing via a position-to-vibration mapping to support attaining a correct posture as part of physical therapy, prevention on apathetic states via a combination of physical inactivity sensing and subsequent activating feedback, and support of eating habits in dementia care by sensing physiological changes that are indicative of hunger to subsequently present eating inducing stimuli (Figure 3b). The specific aim of the latter two concepts was to support elderly to be able to take care of themselves longer. Of the seven generated concepts for *health*, two did not incorporate SA principles.

Design concepts for *navigation* referred to potential innovations for improving safety (n = 7), as well as transportation (n = 2) and choosing musical experiences at festivals (n = 1). These included augmenting the ability to sense obstacles outside the user's attentional scope on the basis of a distance-to-object-to-vibration mapping that indicates an object in the user's path while attention is focused on their mobile phone (benefitting the safety of 'smartphone Zombies'

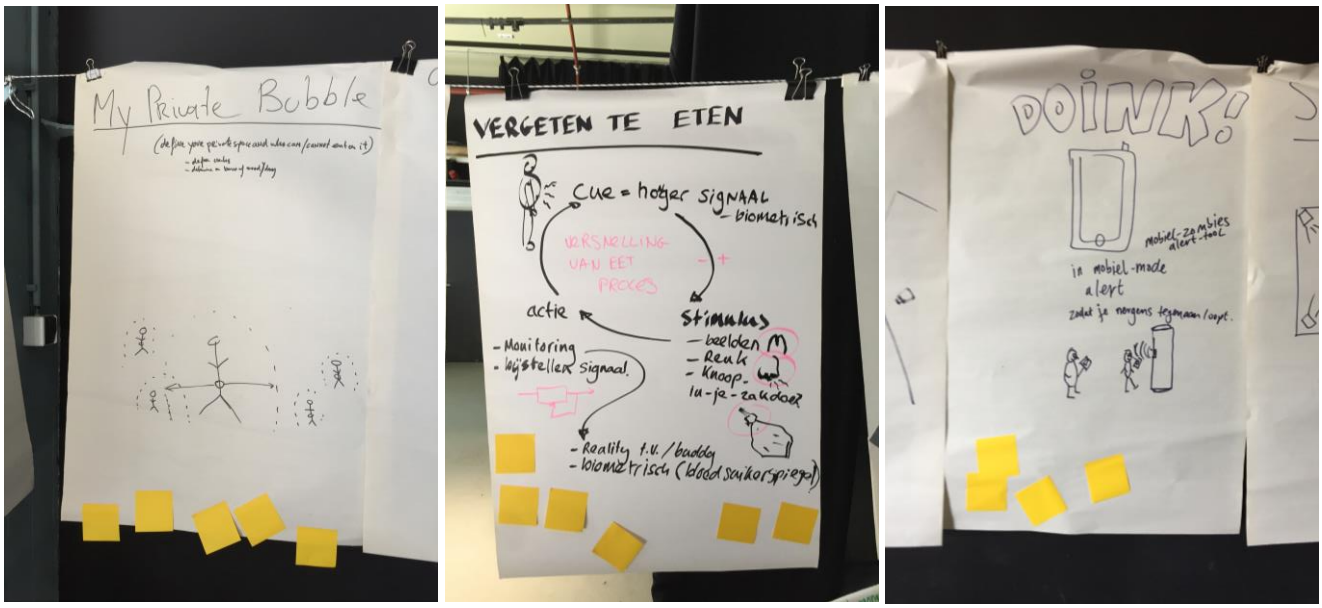

Figure 3. Three examples of design concepts; for a) *social interaction*, suggesting a potential to innovate the management of private space using a distance-to-vibration mapping is awarded five 'points' b) *health*, in which sensory augmentation is applied to dementia care by sensing physiological changes that are indicative of hunger and subsequently presenting eating inducing stimuli, and c) *navigation*, improving the safety of 'smartphone Zombies' by augmenting the ability to sense obstacles outside the user's attentional scope and is awarded four 'points'. ©Michel van Dartel

during navigation through cities (Figure 3c)); and augmenting a user's sense of hearing via an orientation-to-live music mapping that enables users to orient themselves toward a podium at a festival by hearing the music that is playing there while navigating toward it. Of the seven concepts for *navigation*, two did not incorporate SA principles.

Design concepts for *art* in public space suggested a potential to innovate the construction of narratives (n = 2), music making (n = 3), and interfaces (n = 3). These included using SA principles to construct a novel way to navigate a narrative by mapping variable input (such as heart rate, location, time of day) to media fragments and the use of such variable input to play a musical composition in a way mapped to the ongoing weather conditions. As such, SA principles appeared to enable more situated and situationally aware forms of art in public space. However, important to note here is that of the eight concepts for *art* in public space, most concepts for music making (n = 2) and all of the interfaces (n = 3) did not incorporate principles of SA.

Expert and stakeholder evaluations

The ratings of the experts and stakeholders of the design concepts provides further indication regarding interesting starting points for making the innovation potential of SA for public space a reality (Figure 4).

As concepts categorized as having a possible potential for innovation (n = 11) or having no potential for innovation (n = 9) included concepts from each primary application domain, the evaluations indicated that design concepts from all primary application domains held a potential for innovation (n = 6), albeit to a lesser extend for the domain art. In particular, a potential for innovation was attributed to concepts focused on *navigation safety* (n = 2), for humans, i.e., augmented sensing of temperature in order to navigate the coolest route on a hot day, and for animals, i.e. location-aware conditioning of virtual borders with the aim to maintain a desired level of biodiversity; *Health care* (n = 2), focused on supporting elderly to self-care longer, i.e., via the prevention of apathetic states and supporting eating habits through SA; *Play and sports training* (n = 1), i.e., by means of a suit that uses vibrations to give a user error feedback on their posture and movements during work-outs; and *Social interaction* (n = 1), via the augmentation of sensing private space in 360°, enabling new ways to manage private space.

Some design concepts also received profuse criticism from the experts and stakeholders during the plenary discussions and, resultantly, received zero 'points' at the end of the workshop, indicating no current potential for innovation. These concepts were rated as such because these were considered either not feasible, e.g., the concepts for augmented crowd control that used a distance-to-vibration mapping to choreograph movements within large masses, or not original, e.g., a device that conveys orientation during scuba diving. This is noteworthy because neither a lack of feasibility or novelty excludes the possibility of the concept having innovation potential in the longer term.

Overall, these findings underline the observation that there is a broad range of possible design concepts that hold potential for SA in the improvement of public space.

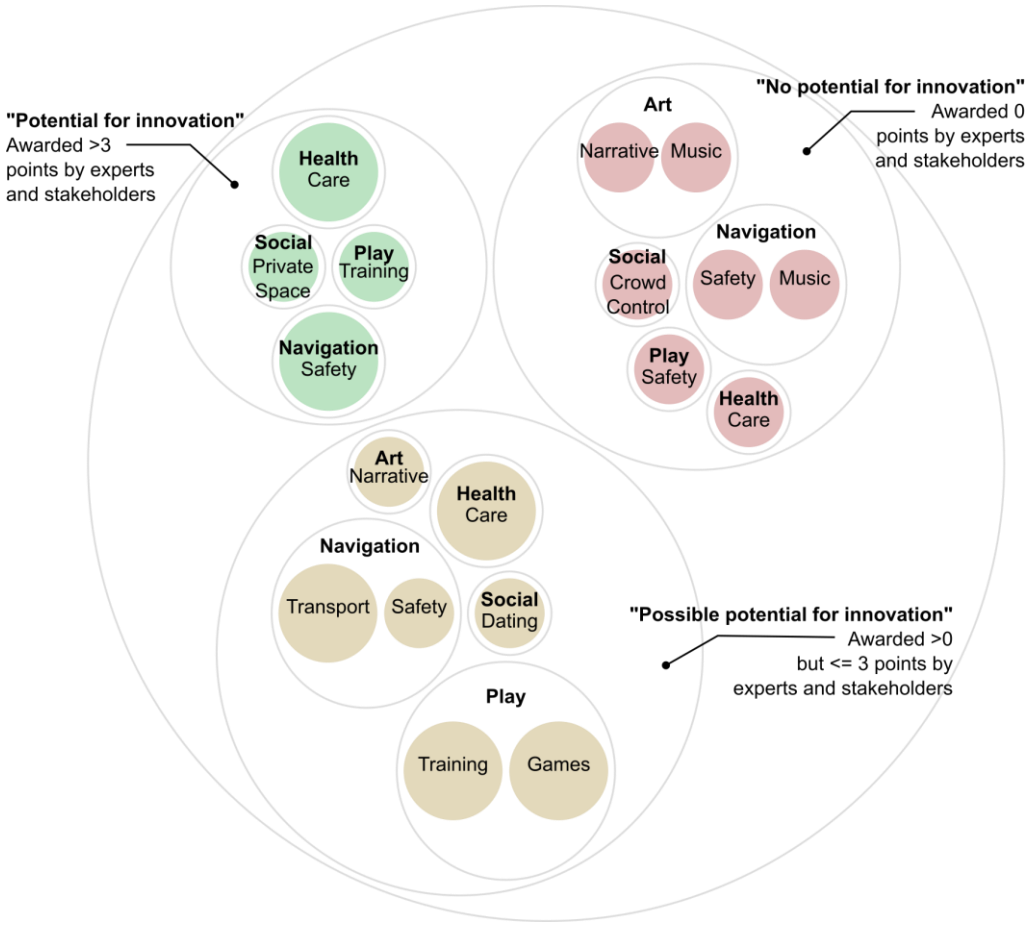

Figure 4. Visualisation of the amount of unique design concepts that incorporate SA principles organised by expert and stakeholder ratings for their innovation potential.

Discussion and conclusion

The present study, provides a first look at the innovation potential of SA for the improvement of public space. The results presented above support previous research suggesting an innovation potential of SA for the domains of play, social interaction, health, navigation and art. For all of these five domains, our findings show that public space should be an area of particular interest to researchers and developers exploring this potential. There, the physical interaction between people and their environment that SA require is abundant, giving rise to a wide range of possibilities for its application.

Our results also identify various secondary application domains that hold innovation potential for SA *within* the five primary domains of health, navigation, play, social interaction and art. These secondary domains may help to guide the ideation of new applications within the primary domains, including those domains of which the innovation potential for SA has already been established. For example, while the innovation potential of SA in navigation applications is already being explored [3], our study indicates that this potential may particularly benefit navigation in public space that is based on music or that addresses transportation or safety challenges. Such an additional level of specificity in guiding the ideation and exploration of SA applications may help in 'matching' the potential of SA with existing challenges.

Another finding is that ideation with respect to the implementation of SA, with the exception of the domains of play and social interaction, sometimes leads to concepts that do not make use of SA principles. Speculatively, this may indicate that these domains may be more challenging to apply SA to or that other, non-SA, concepts are more tempting to apply within these domains. Alternatively, this deviation from SA principles could be explained by the fact that the domains of play and social interaction were addressed in the first two parallel brainstorms, while participants may have experienced fatigue, and resultantly may have been less focused on SA principles, in later brainstorms. These deviations from SA principles were not addressed during the discussions to facilitate the creative thinking process, since ideas that initially do not make the brief may inspire other innovative ideas later on.

Furthermore, the expert and stakeholder evaluations of the design concepts gave rise to the finding that the domain of art may hold less potential for innovation than domains such as play, social interaction, health, and navigation. Of course, the sample size used in this study is not sufficient to draw generalizable conclusions from. Speculatively though,

it may be that SA has already been incorporated within a number of (public) works of art (see [9] for a review). This finding may therefore, albeit indirectly, suggest that it is more difficult to innovate on the basis of SA within the domain of art because its potential for public space is already being explored within this domain. If so, then this aligns with research that suggests that artists should play a role in the innovation process when SA is applied due to their specialized knowledge in the subject. [5, 6] So, rather than innovating the domain of art itself, artists should be involved in innovating other application domains on the basis of SA.

In conclusion, the presented research contributes that the use of SA to improve public space holds a broad potential for innovation. This goes in particular for innovating play, social interaction, health care, navigation, and possibly also for art in public space. As most of these domains are largely unexplored both scientifically and practically, this study provides a starting point for, and guidance in, the application of SA principles for the improvement of public space.

Acknowledgements

The research reported in this paper was financially supported by the National Taskforce Applied Research and the Netherlands Organisation for Scientific Research (KIEM.CRE.03.005).

References

[1] J. Kevin O'Regan. *Why Red Doesn't Sound Like a Bell: Understanding the Feel of Consciousness.* (Oxford: Oxford University Press, 2011).

[2] Árni Kristjánsson, Alin Moldoveanu, Ómar I. Jóhannesson, Oana Balan, Simone Spagnol, Vigdís Vala Valgeirsdóttir and Rúnar Unnthorsson, "Designing sensory-substitution devices: Principles, pitfalls and potentials," *Restorative neurology and neuroscience* 34:5, (2016): 769-787.

[3] Sachar Maidenbaum, Shelly Levy-Tzedek, Daniel Robert Chebat, Rinat Namer-Furstenberg and Amir Amedi, "The effect of expanded sensory range via the EyeCane sensory substitution device on the characteristics of visionless virtual navigation," *Multi-Sensory Research* 27:5-6, (2014): 379-397.

[4] Tom Froese, Marek McGann, William Bigge, Adam Spiers and Anil K. Seth, "The enactive torch," *IEEE Transactions on Haptics* 5:4, (2012), 365-375.

[5] Alwin de Rooij, Michel van Dartel, Antal Ruhl, Hanna Schraffenberger, Bente van Melick, Mathijs Bontje, Mischa Daams and Michel Witter, "Sensory Augmentation: A Dialogue between the Arts and Sciences," in *Proceedings of the 6th International Conference on ArtsIT, Interactivity and Game Creation*, (2018): 213-223.

[6] Antal Ruhl, Alwin de Rooij and Michel van Dartel, "The Artistic Potential of Tactile Vision Interfaces: A First Look," in *Proceedings of the Twelfth International Conference on Tangible, Embedded, and Embodied Interaction*, (2017): 73-79.

[7] Michael Biggs and Henrik Karlsson, *Research in the Arts* (New York: Routledge, 2012).

[8] Arie Altena. "Expert Meeting Sensory Augmentation in Public Space" CARADT.com. https://lectoratenakvstjoost.files.wordpress.com/2018/10/bijeenkomst-saps-v2_04072018.pdf (accessed November 27, 2018).

[9] Madeline Schwartzman. *See yourself sensing. Redefining human perception.* (London: Black dog publishing, 2011).