The 'I' of architectonic perception

Own body perception and bodily feelings in architectonic space

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Introduction

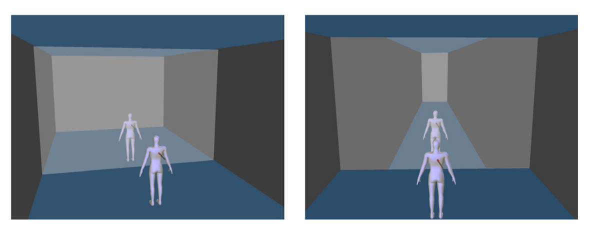
Emotional aspects of extra-personal space with respect to bodily feelings and architectonic space have been argued in the past. For instance, during the nineteenth century somesthetic and physiognomic affinities involving the observer's empathic response to architecture were assumed to be the main aspect of the aesthetic experience [1, 2]. However, knowledge about how the interference of multisensory mechanisms with architecture may contribute to the human experience of the environment has remained sparse. Here, we address the question of how strongly tectonic elements, i.e. the walls, or a modulation of the architectonic interiors contribute to evoking specific bodily states. Recent findings in cognitive neuroscience revealed that visuo-tactile stimulation of subjects could induce a Full-Body-Illusion (FBI) during which self-consciousness was experienced as being disrupted. Based on a previous paradigm involving body parts [3, 4], it was observed that self-identification (SI), i.e. the sense to own a body, and self-location (SL), i.e. the experience of the self at a specific position in space, can be altered through visuo-tactile dissociation and a virtual body seen in peri-personal space [5, 6, 7]. How does the shape of the architectonic interior modulate self-identification and self-location with respect to visuo-tactile association?

Experiment 1: Room-size

Materials and methods

Subjects were placed inside a virtual reality (VR) arena with an active tracking system. They were facing a rear-projection screen on which a life-sized back-facing virtual body was displayed within an architectonic interior, either "large" or "narrow" (2 factors of room-size), i.e. sidewalls in extra- respectively peri-personal space (Figure 1). We manipulated SI by stroking the back of the subject and the virtual body in synchronous or asynchronous visuo-tactile mode (2 factors of stroking synchrony) using a wooden stick on which we mounted an optical marker to track its position. For Synchronous stroking the captured motion data of the marker was projected in real time. Asynchronous stroking was produced with recorded motion data relayed back to the screen with a visible delay. Two by two factors were presented in randomized order. White noise was presented over headphones.

Figure 1:
Subjects were stroked (2 minutes) while watching the back of the virtual body being stroked either in synchronous or asynchronous mode in a "large" or a "narrow" architectonic



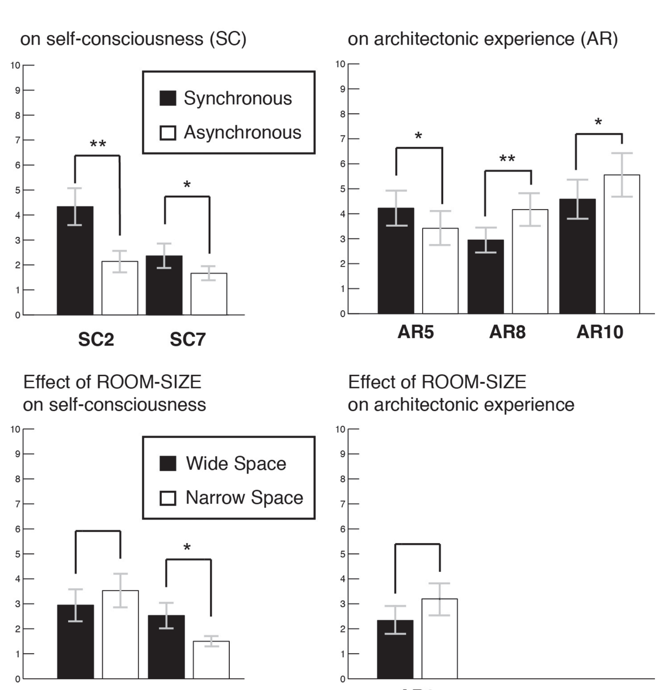
At the end of each experimental block SI with the virtual body was ascertained through a bodily self-consciousness (SC) and an architecture (AR) questionnaire (Table 1). All questions were graded in a one to ten scale corresponding to "not at all" and "very much". Questionnaire scores were analyzed using repeated-measures analyses of variance (ANOVA) with within-participant factors stroking synchrony (synchronous or asynchronous) and room-size (large or narrow). The correlation between global self-consciousness and each question of the AR questionnaire was assessed in a Pearson correlation introducing a global self-consciousness index (SCI) as the mean of the responses to the three first questions of the SC questionnaire.

Table 1: During the Illusion at moments I felt that...
SC1. The touch of the stick was in the location where I saw the virtual body being touched.
SC2. The touch I felt was caused by the stick touching the virtual body
SC3. The virtual body was my body
SC4. My (real) body was drifting towards the front (towards the virtual body).
SC7. The virtual body was drifting backwards (towards my body).
AR5. The sidewalls were located closer to myself than other parts of the room.
AR6. Some elements enclosing the virtual room were almost lightly touching my body.
AR8. Every element of the room was equally far from myself.
AR10. I was standing outside the virtual room.

Results

Analysis of the questionnaire data showed significant two-way interactions. Further analysis in the SC questionnaire revealed a main effect of synchrony with respect to SI and illusory touch with the virtual body for questions SC1 (p=0.000), SC2 (p=0.001) and SC3 (p=0.005). We found an effect of stroking synchrony on room-size, as well as of room-size on SIv (Figure 2). In the correlation analysis with global SCI seven out of twelve questions, including AR5 and AR6, were linearly correlated with an index of (P < 0.05).

Figure 2:
The sensation of drifting forwards **(SC4 p=0.021)** and of the virtual body drifting backwards **(SC7 p=0.021)** were significantly associated with **synchronous stroking**. A significantly higher score with respect to stroking synchrony was observed for a presumedly close location of the sidewalls **(AR5 p=0.046)**, while asynchronous stroking was more effective in inducing the feeling of standing outside the virtual room **(AR8 p=0.001; AR10 p=0.049)**.
The effect of the narrow interior on the factor **room-size** showed a trend in **(AR6 p=0.053)** and **(SC2 p=0.059)**. Backward drifting of the virtual body was significantly stronger for the walls in extra-personal space **(SC7 p=0.022)**.



"Felt" interiors: the phenomenology of architectonic space

Large room-size
The most realistic estimation was performed in the large room-size during synchronous stroking. Room perception after asynchronous stimulation was subject to a slight underestimation of room width.

Narrow room-size
Narrow synchronous was the factor driving the interaction. Not only was the room perceived as being shorter, but also width was understimated. Subjects reported the feeling of being slightly touched by the sidewalls and after the narrow synchronous condition subjects perceived the sidewalls drifting towards them.

Synchronous stroking
For both synchronous conditions, large and narrow, subjects felt as if they had been standing on two spots simultaneously.

SPACE

LIGHT GREY	Effective room geometry
DARK GREY	Perceived interior

BODY

BLUE	Felt position of the subject
LIGHT BLUE	Seen position of the virtual body
TRANSPARENT	Effective position of the subject

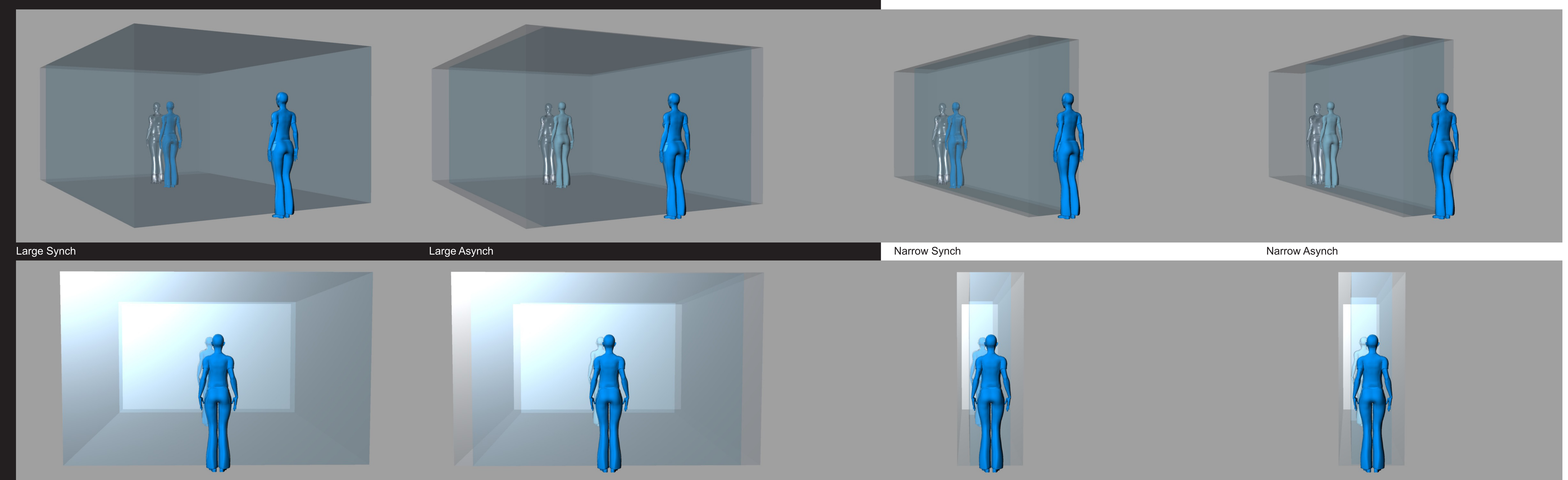
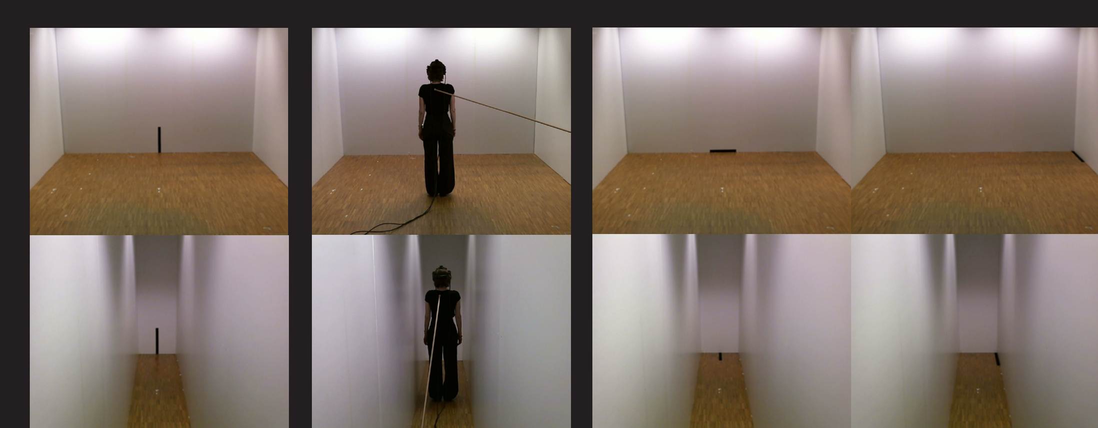
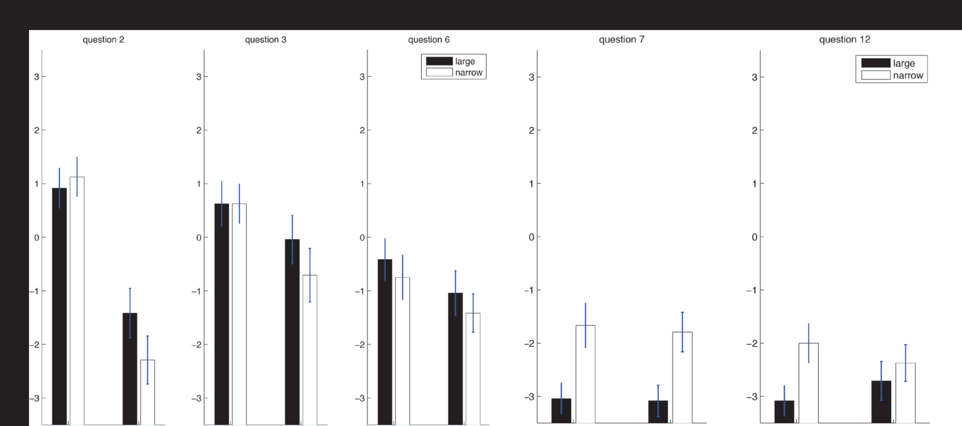


Figure 3:
Subjects were asked to memorize the vertical reference bar (a). After stimulation (b) on the HMD they were shown 20 pictures with bars (40-80 cm) randomly ordered in the respective room-size (c).
In all cases subjects had to estimate the length of the bars in a forced choice task by choosing between the two options 'shorter' or 'longer', as compared to the vertical reference bar. Responses were collected by a joystick.



a) Reference bar b) 2 min stroking c) 20 estimations

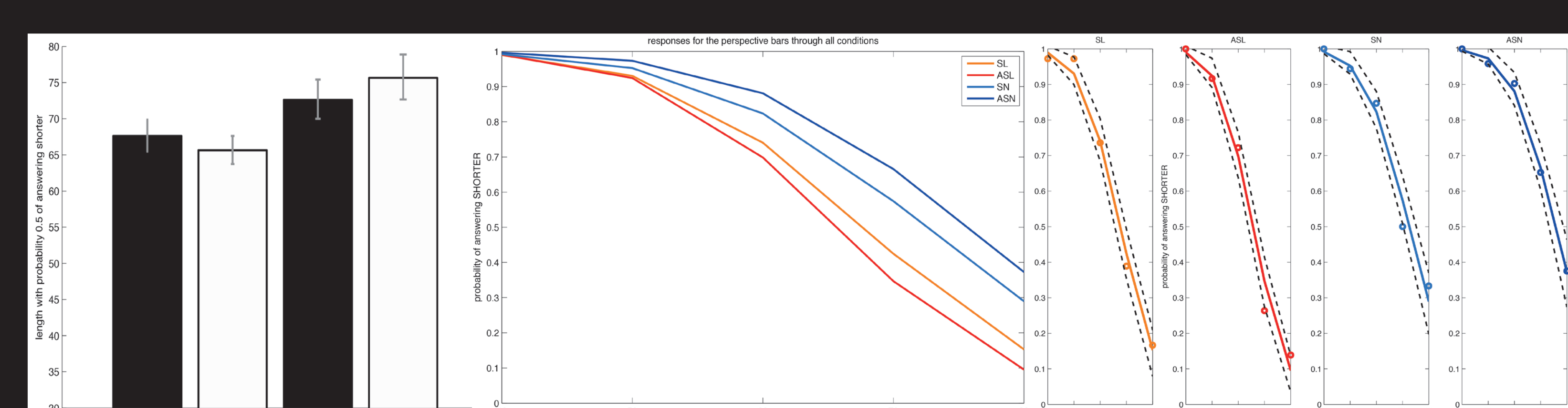
Figure 4:
Two questions showed significant variation with respect to **room-size**: question AR7 (p =0.0002) and AR12 (p=0.0193) (figure 4). Post-hoc tests showed the effect of room-size on question 12 was mainly driven by the synchronous case (p=0.010986).
Question 6 showed a trend to significance (p=0.0973).



a) Stroking synchrony b) Room-size

Table 2: During the past moments sometimes…
SC1. I was feeling the touch of the stick where I saw the virtual body being touched.
SC2. I felt that the stick touching the virtual body was causing the touch I was feeling.
SC3. I felt that the virtual body was my body.
AR7. I felt as if the walls of the room were almost lightly touching me.
AR12. I felt as if the walls were getting closer to myself.

Figure 5:
To address whether the stroking synchrony by room-size interaction was driven by the large or narrow interior we repeated probit analysis considering estimations corresponding to room-size conditions separately. In result, the **synchronous narrow room-size** condition appeared to be the factor driving the interaction (p=0.0493).



a) Bars: LS LAs NS NAs b) Interaction between factors c) Single curves

Experiment 2: Geometry

Materials and methods

We replicated setup and procedures of Experiment 1 in video-based VR filming the subjects from behind and projected the image on a head mounted display (HMD) worn by the subjects. The cameras were centred on the backside of either room, aligned at the same distance and directed toward the front wall. To change the room-size we used 4 custom-made panels. For synchronous stroking the image captured from the webcams was directly relayed to the HMD. For asynchronous stroking a delay of 800 ms was added. In addition to questionnaires we introduced a length estimation task to assess the perception of architectonic space (Table 2). The stimulus to solicit length estimation was delivered by images captured previously. A vertical black bar placed at the bottom of the white front wall was the reference bar. 20 bars were presented for the estimation task (Figure 3). Length estimations were analyzed using probit analysis. To our knowledge, probit analysis has never been used in experiments addressing body ownership therefore we also considered probability thresholds for subjective estimation.

Results

Questionnaires showed two-way interactions. We performed paired t-tests for individual questions for a main effect of synchrony or room-size. Significance was confirmed with a Wilcoxon non-parametric test. Questions showing a significant variation with the synchrony factor in both tests were questions 1 (p<0.0000), 2 (p<0.0000), and 3 (p=0.0381). Post-hoc analysis showed that in question 3 the impact of synchrony was mainly driven by the narrow condition (p=0.0032). We also found that stroking synchrony had influenced the perception of room-size significantly (Figure 4).
When considering all bars presented in perspective, a significant factor room size and the interaction factor stroking synchrony by room-size was observed (p=0.0182) (Figure 5).

Conclusion

In our experiments about multisensory perception of architectonic space we found that visuo-tactile disruption of bodily self-consciousness interferes with the self-attribution of virtual architectonic interiors influencing self-identification with the virtual body.

It appeared that the variation of dimensions of an architectonic interior, i.e. large and narrow with respect to extra- and peri-personal space, was differently perceived when subjects self-identified with the virtual body. For the first experiment, our questionnaire data supports the hypothesis of an increased stimulus detection in peri-personal space inducing an improved self-attribution of the tectonic elements also enhancing their bodily stability. The behavioural measure reported in the second experiment shows that synchronous stroking may induce an embodied perception of the rooms through self-identification with the virtual body.

Overall, we found the effectively perceived geometries of the interiors to depend on the position of the visual stimulus in the extra- or peri-personal space of the observer. In the large room the sensation of space was induced by the "sunk" front wall and in the narrow interior by the converging sidewalls.

Acknowledgements

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References

1 Vischer, Robert, 1873. On the optical sense of form: a contribution to aesthetics
2 Wölfflin, Heinrich, 1886. Prolegomena to a Psychology of Architecture
3 Botvinick M, Cohen J, 1998. Nature no. 391 (6669):756.
4 Graziano MS, Cooke DF, and Taylor CS, 2000. Science no. 290 (5497):1782-6.
5 Ehrsson HH, 2007. Science no. 317 (5841):1048.
6 Lenggenhager B, Tadi T, Metzinger T, and Blanke O, 2007. Science no. 317 (5841):1096-9.
7 Aspell JE, Lenggenhager B, and Blanke O, 2009. PLoS One no. 4 (8):e6488.