Short-term occupancy implications of digitally provided outside views in window-less rooms

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1. ABSTRACT

This paper investigates the perception and performance of occupants in rooms with and without visual connection to outside. Thereby, experiments were conducted with two groups of participants in a laboratory containing two test cells. One of the cells is equipped with a flat panel display, which acts as a virtual window. The other cell has no such display. Participants in the experimental group were exposed, via the virtual window, to different scenes. The control group in the window-less room was not exposed to such treatment. During the experiments, participants were asked to fill in a questionnaire regarding indoor environment. Additionally, they were asked to perform a number of typical problem-solving tasks. The discussion of the experimental results addresses the question, if and to which extent the existence of a virtual connection to the outside world in window-less spaces can improve occupants' perception and performance.

2. INTRODUCTION

Windows are considered to be an essential element of the building envelope. They connect the inhabitants to the outside world, provide information regarding the surrounding environment, and admit daylight and solar radiation into the building. Accordingly, the presence and appropriate functionality of windows is considered to be of utmost importance regarding health, comfort, and productivity of people living and working in interior spaces. A number of previous suggest that presence of elements such as windows, monitors, plants, luminaires, etc. in rooms have an effect not only on the room perception but also on occupants' performance and productivity (Mossböck 2005, Maslow and Mintz 1956, Mintz 1956, Tsunetsugu et al. 2005). Given this background, a number of interesting research questions arise: Can certain positive effects associated with real windows be also triggered via virtual (digital) "windows"? Does provision of a kind of coupling to the exterior environment via a digital display improve occupants' evaluation of a room? In this context, this paper investigates the perception and performance of occupants in rooms with and without visual connection to outside. Thereby, experiments were conducted with two groups of participants in a laboratory containing two test cells. One of the cells was equipped with a flat panel display, which acted as a virtual window. The first group of participants was exposed, via the virtual window, to different scenes (e.g., urban sceneries, rural landscapes). The second group was not exposed to such treatment. During the experiments, participants were asked to fill in a questionnaire involving a cognitive/emotional self-assessment as well as their perception of the indoor environment. Additionally, they were asked to perform a number of typical problem-solving tasks. The paper presents the results of these experiments. The discussion addresses the question, if and to which extent the existence of a virtual connection to the outside world in window-less spaces can improve occupants' perception and performance.

3. METHOD

Experiments were conducted with two groups of participants in a laboratory with two test cells (each with a floor area of 12 m²), which have no visual connection to the outside environment. One of the cells is equipped with a flat panel display, which acted as a virtual window. The other cell has no such display. Each of the cells contains 6 working spaces (see Figure 1 and 2).
The first (experimental) group of participants was exposed, via this virtual window, to different scenes (e.g., urban sceneries, rural landscapes). The second (control) group was not exposed to such treatment. During the experiments, participants were asked to fill in a questionnaire pertaining to their assessment of the indoor environment as well a self-assessment of their own emotional state. Moreover, they provided solutions to a

number of problem-solving tasks. The overall purpose of the experiment, the virtual window, and the questionnaire were not discussed with the participants to avoid bias.

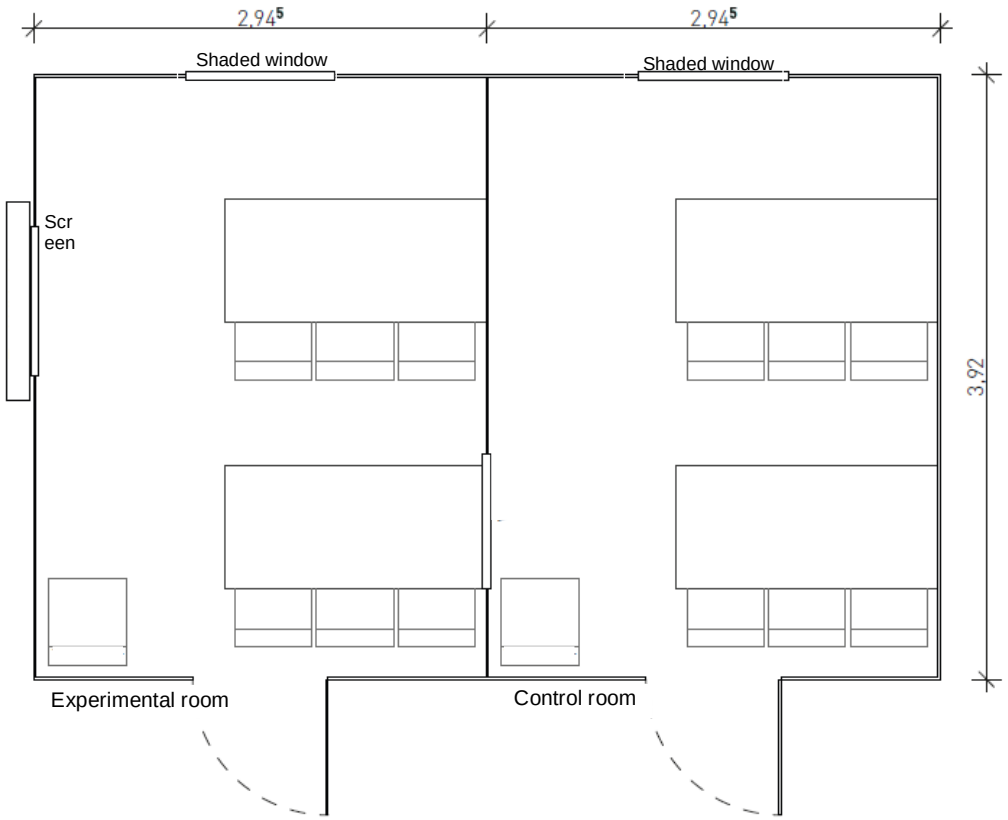

Fig. 1: Floor plan of the two test cells

Fig. 2: Views of the test cells

During the test series, videos ran on the virtual window. Three different videos (see Figure 1) were used, showing different locations (park, pedestrian street, and landscape).

The distributed questionnaire included three components:

- Self-assessment of participants' emotional state using a semantic differential (at the beginning of the experiment). Thereby, six (five-point) scales were deployed as follows: *i)* stressed/relaxed, *ii)* tired/fresh, *iii)* bored/interested, *iv)* poor mood/good mood, *v)* unmotivated/motivated, and *vi)* unwell/well.
- Evaluation of the room using a semantic differential (at the beginning and at the end of the experiment). Thereby, three (likewise five-point) scales were deployed as follows: *i)* unfriendly/friendly, *ii)* boring/stimulating, and *iii)* tight/spacious.
- Performing three typical problem-solving tasks (during the experiment). These tasks involved mostly geometric problems (3-D spatial perception and imagination).

The experimental group and control group consisted of 146 and 289 individuals respectively. Thereby, 66 male and 75 female participated in the experimental group, and 131 male and 144 female in the control group. Participants were young bachelor students (90% between the age of 19 and 25) with technical background. Test series were conducted in small groups (maximum 6 people). Each test run took approximately 15 minutes.

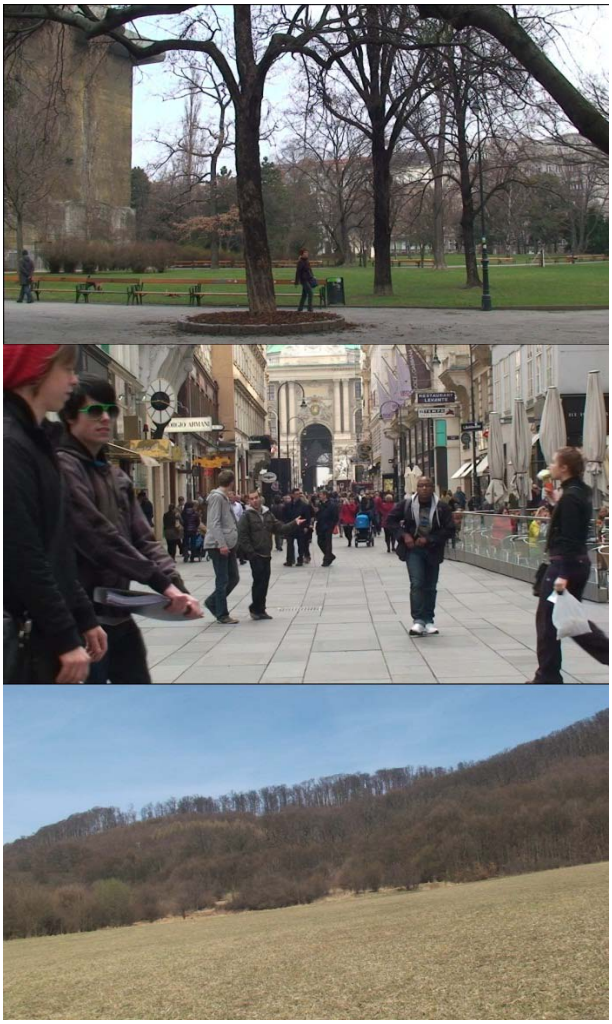

Fig. 3: Snapshots from the deployed videos (T1: top; T2: middle; T3: bottom)

4. RESULTS

Figure 4 shows the results of the experiments in terms of a semantic differential. Participants' self-assessment is captured in the upper six scales (stressed/relaxed, tired/fresh, bored/interested, poor mood/good mood, unmotivated/motivated, unwell/well). Participants' assessment of the test/control room are captured in terms of the lower three scales (unfriendly/friendly, boring/stimulating, tight/spacious). In this Figure, T1, T2, and T3 refer to the three video exposures (see Figure 3) and T denotes the mean results for all three video exposures. C denotes the control group results. Figure 5 shows the results of the problem-solving component

of the experiments. The results are expressed in terms of the percentage of correct solutions to the three problem-solving tasks. In this Figure, T denotes the experimental group and C the control group.

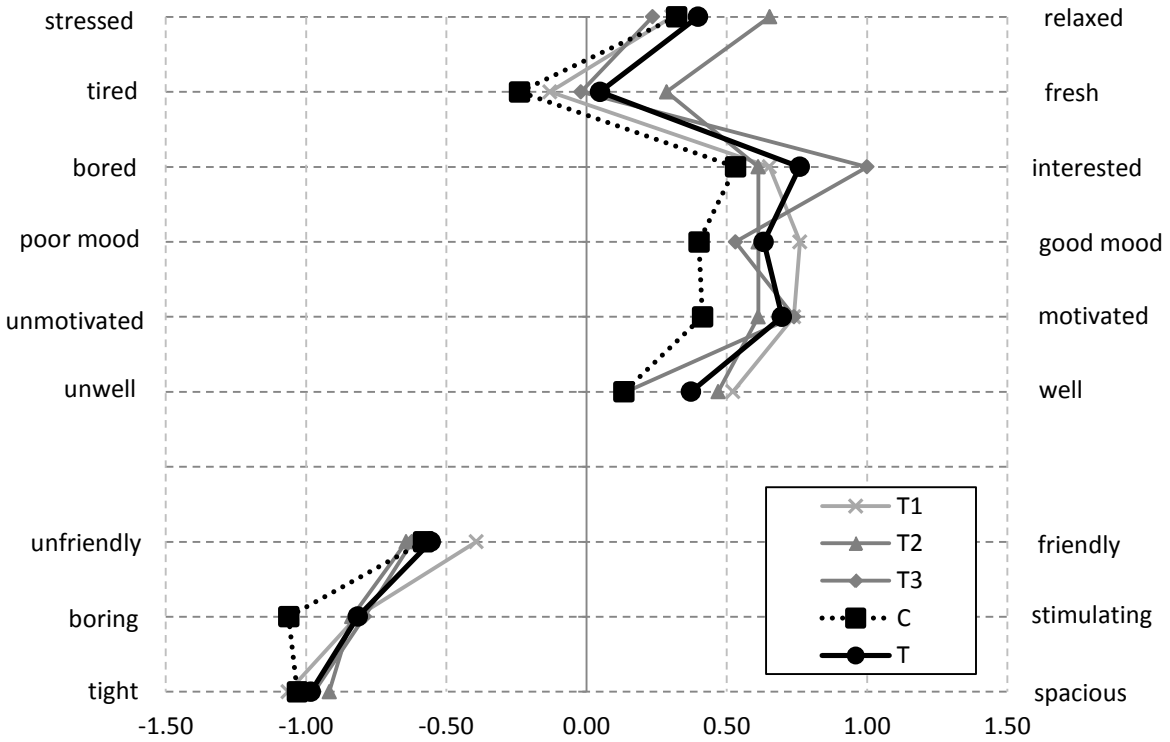

Fig. 4: Semantic differential with participants' self-assessment (the upper six scales) and room assessment (the lower three scales). T1, T2, and T3 refer to the three video exposures (see Figure 3). T denotes the mean results for all three video exposures. C denotes the control group results.

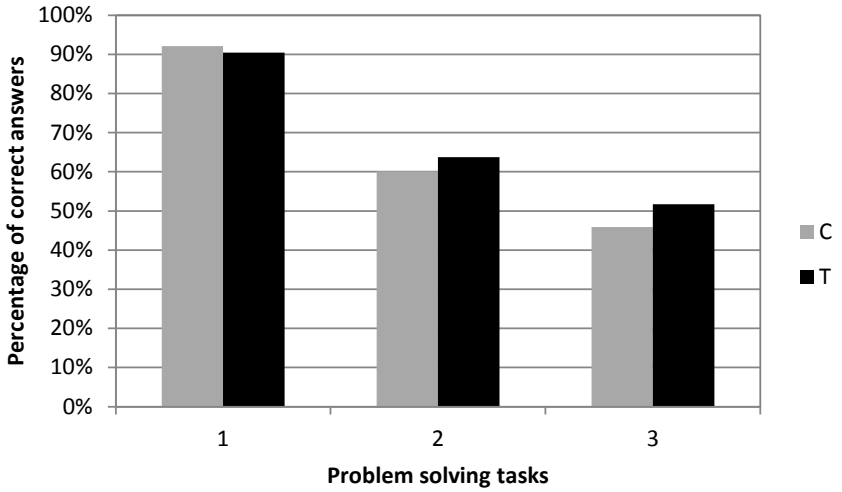

Fig. 5: Percentage of correct answers to the three problem-solving tasks (T: experimental group, C: control group)

5. DISCUSSION AND CONCLUSION

The results suggest that the experimental group's self-assessment of their emotional state was more positive than the control group. Likewise, the experimental group evaluated the test cell more positively (Figure 4). No noteworthy difference between the three videos could be discerned. However, in cases with video images that involved a connection to a non-bounded outdoor environment (open landscape or park), participants perceived the test cell to be slightly smaller: Participants had been asked, in a separate question, to estimate

the test cell's floor area. In exposure cases T1 and T3, the floor was estimated to be smaller than in the exposure case T2.
The problem solving performance appears to have been also somewhat higher in case of the experimental group (questions 2 and 3, Figure 5). Thus, the presence of a virtual connection to the outside environment appears to have positively affected participants' self-assessment, room evaluation, and task performance.
However, it is important to qualify this assertion: The differences between the experimental and control group are consistent, but statistically not significant. The effect of the virtual window was quite small. One contributor to this circumstance could be the virtual window's rather small size. Moreover, in the experiment's design the conscious decision was made that the test participants would not sit facing the display (in order not to make it to conspicuous). A frontal arrangement might have accentuated the virtual window's effect. Another factor that might have inhibited the virtual window's effect in this case was the rather short duration of the overall exposure and the corresponding short adaptation time.
Future experiments will thus address a larger and technically more advanced virtual window, and different arrangements of its location vis-à-vis occupants' seating arrangement. Moreover, longer exposure times and a more varied demographics in the composition of the experimental and control groups will be targeted.

6. REFERENCES

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7. ACKNOWLEDGEMENTS

The authors wish to acknowledge the contribution by Christian Sustr, Andreas Wurm, Matthias Jahn, Evamaria Schmidthaler, Julia Marchgraber, Lisa Mattanovich, Jan Slezak, and Iris Lukanowicz toward designing and conducting the experiments described in this paper. The authors also gratefully acknowledge the contribution of Dr. Matthias Schuss toward the installation and configuration of the equipment needed for the experiments.