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Effects of Opaque Patterns on Desk Partitions on Sense of Enclosure in the Work Environment

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ABSTRACT

Desk partitions are widely used in office environments to enhance concentration by blocking visual stimuli. However, excessive enclosure can induce a sense of confinement, potentially hindering communication and collaboration. This study explores desk partition designs incorporating opaque patterns, such as gradient and uniform opacity, to mitigate confinement while maintaining focus. Two virtual reality experiments were conducted to examine user preferences and psychological effects. In Experiment 1, participants adjusted partition opacity and height in a virtual office to create an optimal environment for concentration. The results indicated that environmental factors such as ceiling height and desk size had minimal impact on partition preferences. In Experiment 2, the influence of gradient patterns and top-edge opacity on the sense of confinement was analysed. Higher top-edge opacity led to taller preferred partitions, while gradient patterns reduced perceived confinement. These findings contribute to office design strategies that balance privacy and collaboration, optimizing workspace comfort and productivity.

Keywords: Desk partition, Work environment, Workspace, Sense of enclosure, HMD, Virtual reality

INTRODUCTION

In contemporary office environments, desk partitions (henceforth referred to as "partitions") are widely employed to create semi-private workspaces that facilitate concentration. By enclosing a worker's desk on three sides, partitions effectively shield against external visual stimuli, thereby enhancing focus while maintaining a degree of openness.

Matsudo et al. (2019) highlighted the significance of partitions in shaping the subjective evaluations of workspace environments. Their study found that office workers preferred configurations where "low partitions divide desks," associating this feature with enhanced perceptions of personal space, improved work efficiency, and an overall sense of relaxation. Similarly, Shiraishi et al. (1993) investigated the psychological effects of the partition height in open-plan layouts and concluded that a partition height of approximately 30 cm from the desktop surface optimally balances privacy and openness.

Although partitions serve to mitigate distractions and promote concentration, excessive enclosures may induce a sense of confinement,

negatively affecting workplace satisfaction. Akiyama et al. (1996) examined the tradeoff between privacy and communication in office settings, revealing that physical elements such as partitions and desk layouts elicit conflicting evaluations regarding these aspects. Specifically, although partitions enhance privacy, they may simultaneously hinder communication, necessitating behavioral adaptations among workers to mitigate spatial limitations.

The recent shift toward open-plan office layouts has further complicated the balance between privacy and interaction. While open-plan designs foster collaboration, Kim and de Dear (2013) and Brennan et al. (2002) underscore their drawbacks, including increased noise levels and diminished workspace satisfaction. Consequently, contemporary office designs increasingly seek solutions that provide both privacy and flexibility in interactions.

This study examined the psychological impact of partition designs that incorporate opaque patterns as a means of visual segmentation while mitigating feelings of enclosure. Semi-transparent materials have been widely adopted in office settings to preserve spatial openness while delineating individual work areas. Additionally, opaque gradients, which are commonly utilized in windows and partitions, enable selective visual obstruction while retaining a degree of transparency. These gradients that are often applied through films featuring printed dot patterns transition from transparency at the bottom to opacity at the top or dynamically adjust the opacity to align with eye level.

In this study, opaque gradients were defined as partitions exhibiting a linear transition in opacity from the bottom to the top, achieved through continuous rather than dotted patterns (Figure 1). This study aimed to evaluate how these patterns influence the perceptions of enclosure and concentration in office environments. By examining the interplay between partition opacity and perceived enclosure, this study contributes to the optimization of office space designs to better accommodate workers' psychological and functional needs.

Figure 1: A wall with an opaque gradient.

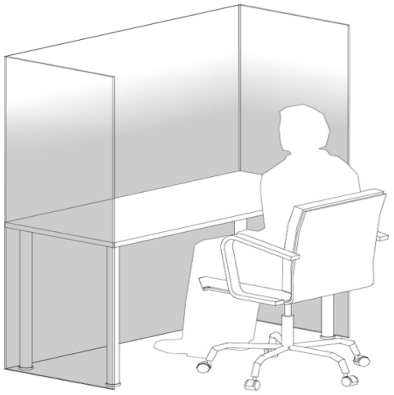

Figure 2: A partition with an opaque gradient.

EXPERIMENT 1

Methods

Participants and Materials

Five university students (four men and one woman) voluntarily participated in the study. The participants were recruited via direct invitations within the university community. The inclusion criteria were normal or corrected-to-normal vision and no reported history of severe motion sickness. The age range of the participants was 21–22 years.

The experiment was conducted using a Vive Pro Eye head-mounted display with a resolution of 1440×1600 pixels per eye and a field of view of 110 °. The Virtual-Reality (henceforth referred to as "VR") environment was rendered on a desktop computer with an Intel Core i7-7700 CPU, NVIDIA GeForce GTX 1080 GPU, and 16 GB of RAM.

The virtual office environment was developed using Vizard6 version 6.3, a virtual reality development toolkit from WorldViz. The software was configured to render the environment at a consistent frame rate of 90 frames per second to minimize motion sickness. The lighting conditions were kept consistent across all virtual scenarios.

Experimental Conditions

Three distinct virtual office environments were constructed with ceiling heights of 2500 mm, 3000 mm, and 3500 mm. Participants were seated at a virtual desk (1500 mm wide, 600 mm deep) with a computer interface resembling a real-world workstation. They adjusted partition settings using a keyboard as part of the experimental task. The conditions for each ceiling height and the initial partition settings are shown in Figure 3.

Initial partition parameters were: base height 1150 mm, upper gradient 1000 mm, lower gradient 850 mm, and upper opacity 50%. Adjustments were made in 10 mm increments using the keyboard, with continuous changes possible by holding down a key.

Each environment included five humanoid avatars simulating office activity. One was seated, one faced the participant, one stood in the space, and two moved along the sidewalls at 1.4 m/s. Their appearance, behavior, and movement remained consistent across all conditions.

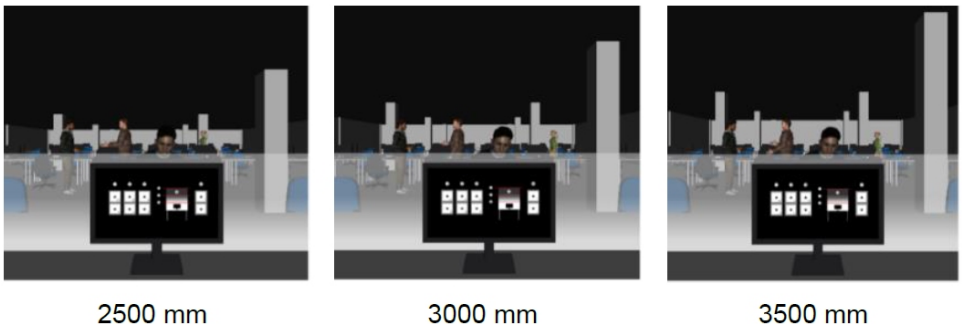

Figure 3: The conditions at each ceiling height and the partition height at the initiation of adjustment.

Experimental Procedure

Before the main experiment, the participants completed a practice session to familiarize themselves with the VR setup, including navigation, partition adjustments, and interaction with virtual elements.

Each trial began with a 10-second exposure to the virtual office environment without partitions. Subsequently, the partitions appeared according to the predefined settings described above. Following this, partitions appeared, allowing the participants to adjust their settings. After the adjustments were completed, the values for each setting were recorded (Figure 4).

To counterbalance order effects, the sequence of ceiling height conditions was randomized using a Latin square design. The participants were instructed to maintain a consistent posture and took short breaks of 1 minute between conditions to reduce fatigue.

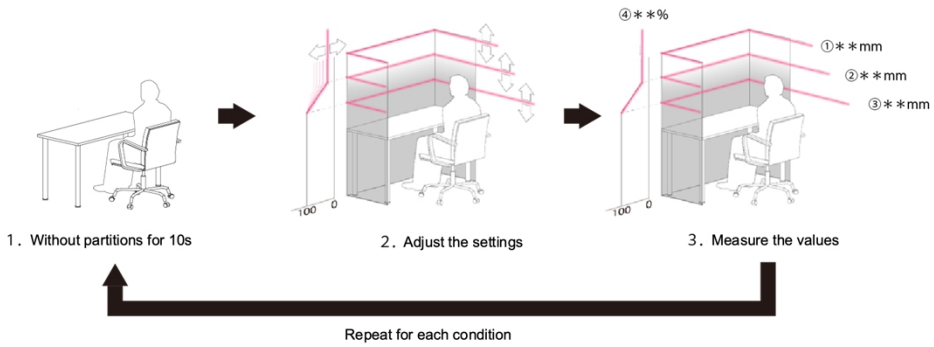

Figure 4: Experimental procedure.

Data Analysis

The primary dependent variable was self-reported concentration rating of the participants. A repeated-measures ANOVA was used to compare the concentration ratings across the three ceiling heights (2500, 3000, and 3500 mm). Post hoc tests (Bonferroni-corrected) were conducted to examine pairwise differences between conditions if the ANOVA revealed a significant main effect. The alpha level for statistical significance was set at $p < 0.05$. Statistical analyses were performed using Python.

Results and Discussion

Figure 5 illustrates the adjustment values for the partition height, gradient width, and upper opacity across different ceiling heights. Although the ceiling height did not significantly influence the partition adjustments, the participants consistently converged in similar settings to optimize their perceived concentration.

Although some individual differences were noted, typical values included an average partition height of 1576 mm, suggesting a preference for moderate enclosures. The opaque gradient of width averaged 350 mm and the lower gradient height averaged 1100 mm, indicating a desire to minimize distraction without complete isolation. The average upper opacity of 59% further supports the balance between focus and a sense of openness.

These findings indicate that individuals prioritize visual and psychological comfort in their immediate workspace configuration, regardless of the ceiling height. The consistent selection of a partition height of approximately 1576 mm implies that a moderate enclosure may enhance the concentration without excessive isolation. Similarly, the balance reflected in the average upper opacity and lower gradient height indicates a preference for maintaining a degree of visibility while minimizing peripheral distractions, which is particularly relevant in environments where both privacy and collaboration are important.

The results highlight the importance of local spatial adjustments such as flexible partitions over overarching architectural elements such as ceiling height in creating concentration-friendly workspaces. Experiment 2 builds on these findings by exploring how the gradient opacity distribution specifically influences perceived concentration, potentially refining the identified optimal partition settings.

EXPERIMENT 2

Method

Participants and Materials

Nine male university students voluntarily participated in Experiment 2. The recruitment criteria were the same as those in Experiment 1: normal or corrected-to-normal vision and no history of severe motion sickness. Due to resource constraints, the sample size remained small, which aligned with the exploratory nature of the study.

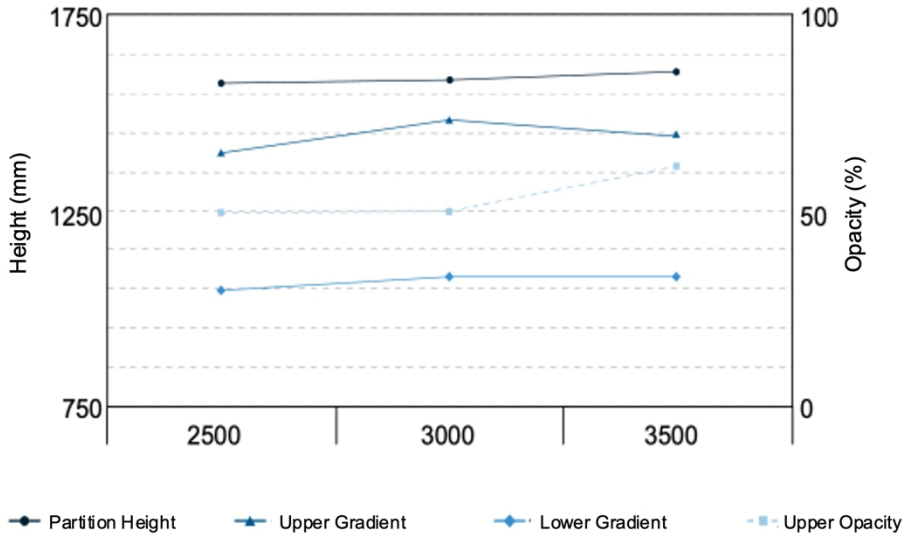

Figure 5: Adjustment values of four setting items for each ceiling height.

The experiment utilized the same VR hardware and software as in Experiment 1 (Vive Pro Eye HMD, Vizard6 version 6.3), ensuring consistency in rendering quality and environmental settings. The virtual office environment, including spatial arrangements and lighting conditions, was maintained identical to that in Experiment 1, with the exceptions noted below.

Experimental Conditions

In contrast to Experiment 1, the opacity pattern of the partitions was the primary manipulation used in Experiment 2. The upper section of the partition featured 10 different patterns derived from five opacity levels, each presented with and without a gradient effect (see Figure 6 for pattern examples). These patterns were designed to assess their influence on the participants' perceptions of the enclosure. The semi-transparent upper section was fixed at a height of 200 mm.

Unlike Experiment 1, the participants only adjusted the height of the front partition, which was initially set at 1150 mm. The goal was to determine the height at which the participants no longer experienced a sense of enclosure. The final adjusted heights were recorded, with higher values indicating a mitigating effect of opacity pattern on enclosure perception.

The virtual office environment included two humanoid avatars. One avatar was seated at a desk and engaged in a typing task, whereas the other moved back and forth at 1.4 m/s. To prevent unnatural movement artifacts, walls were placed on both sides to obscure the walking animation.

Experimental Procedure

The participants first completed a familiarization session to ensure comfort with the VR system and adjustment controls. During the main trials, the

participants were introduced to the virtual office environment and instructed to adjust the height of the front partition using a keyboard. Adjustments were made in 10 mm increments, with continuous modification possible by holding down the adjustment key. The participants were instructed to continue adjusting their height until they no longer felt enclosed. Final adjusted heights were recorded.

To control for order effects, the sequence of the opacity pattern conditions was randomized across participants. Consistent with Experiment 1, participants were instructed to maintain a stable posture throughout the trials. Short breaks were provided between conditions to minimize fatigue and carryover effects.

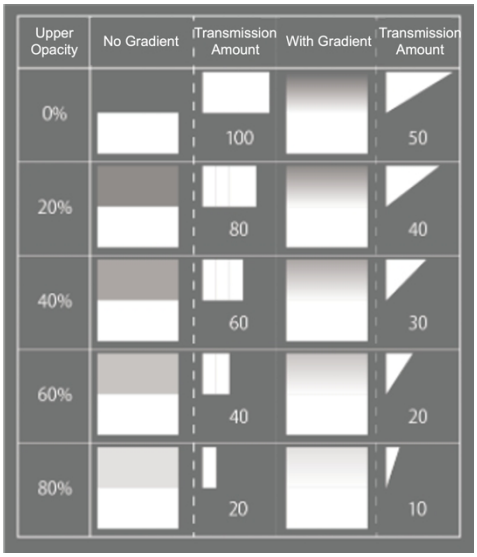

Figure 6: Gradient patterns and transmission amount.

Results and Discussion

Figure 7 shows the adjusted partition heights for each condition and level. A two-way ANOVA was conducted with gradient presence and top opacity level as factors. Analysis of Variance (ANOVA, $P < 0.05$). The main effect of the gradient was significant, with a moderate effect size ($F(1,8) = 80.8218$, $p = 0.0000$, $\eta^2 = 0.0801$). The main effect of top opacity level was also significant with a large effect size ($F(4,32) = 21.7949$, $p = 0.0000$, $\eta^2 = 0.1494$); however, their interaction was not significant ($F(4,32) = 1.8335$, $p = 0.1467$, $\eta^2 = 0.0086$).

Multiple comparisons using Shaffer's modified sequentially rejective method showed that partitions with 0%, 20%, and 40% opacities were significantly higher than those with 80% opacity ($p = 0.0002$, $p = 0.0018$, and $p = 0.0133$, respectively). Similarly, partitions with 0%, 20%, and 40% opacities were significantly higher than those with 60% opacity ($p = 0.0067$, $p = 0.0153$, and $p = 0.0301$, respectively). These results suggested that the perception of the enclosure changed at approximately 40% opacity.

Regarding the higher adjusted heights for "no gradient" partitions compared to "with gradient" partitions, it is possible that the total light transmission (referred to as "transmission amount"), which integrates the opacity of the semi-transparent section, was greater in the "no gradient" condition. This may have contributed to the reduced sense of enclosure. However, despite having the same transmission amount, the adjusted heights for "20% opacity with gradient" and "60% opacity without gradient" differed. This indicates that the amount of transmission alone does not determine the sense of enclosure, and an optimal opacity level may exist at approximately 40%.

Additionally, the perception of enclosure may be influenced by other visual and cognitive factors such as contrast sensitivity, depth perception, and prior experiences with similar spatial configurations. For example, partitions with a lower contrast between transparent and opaque sections may create stronger visual separation, enhancing the sense of enclosure. Similarly, depth perception can affect how individuals interpret spatial boundaries, whereas prior experiences may lead to different expectations of enclosure levels.

Furthermore, the role of perceptual adaptation should be considered. The participants may have subjectively adjusted their perceptions based on their prolonged exposure to the partitions. This adaptation effect could result in a gradual change in the perceived level of enclosure over time, suggesting that initial impressions may differ from those of long-term spatial evaluations. Future studies should investigate how these perceptual adjustments evolve with extended exposure and whether they influence occupant preferences in real-world environments.

These findings provide insights into the influence of opacity levels and gradient effects on spatial perception. These results suggest that partitions with a lower opacity and no gradient allow for greater perceived openness, thereby reducing the psychological sensation of confinement. This has practical implications for office and workspace designs, where optimal partition configurations can be tailored to enhance occupant comfort.

CONCLUSION

This study examined the effectiveness of desk partitions with varying opacity patterns in reducing the sense of enclosure while maintaining a focused workspace. Through two experiments conducted in a virtual office environment, we found that ceiling height had a minimal impact on participants' partition height and opacity adjustments, supporting the notion that local spatial modifications are more influential than overarching architectural features.

A key threshold for enclosure was identified as an opacity of approximately 40%, suggesting that transparency levels significantly influenced perceived openness. Additionally, partitions with non-gradient patterns were adjusted to greater heights, indicating that the pattern itself, beyond transparency, affected enclosure perception. The lack of a significant interaction effect between gradient presence and opacity further supports the notion that their influences are independent.

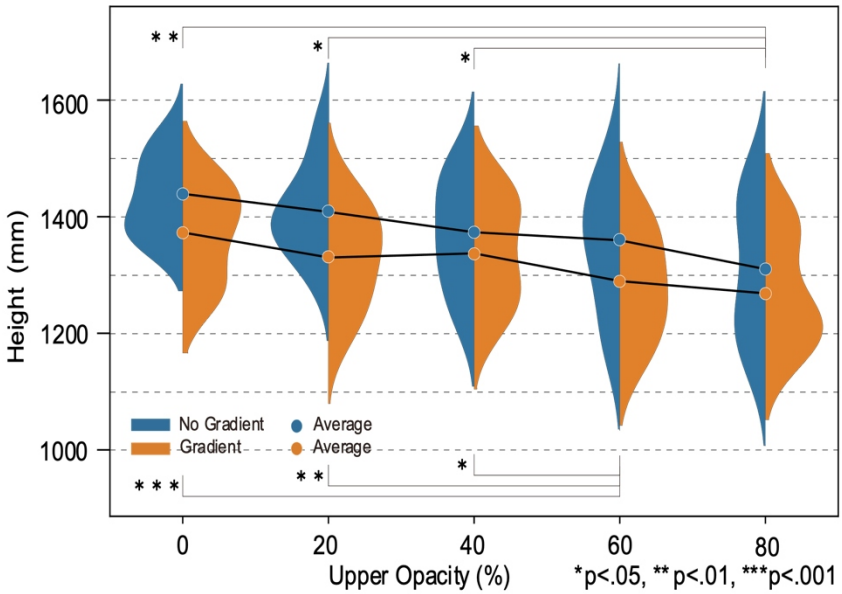

Figure 7: The height of the partition after adjustment under each condition.

These findings have practical implications for office design, suggesting that strategically adjusting the partition opacity and patterns can optimize workspace layouts to enhance concentration. Future research should explore additional factors such as individual differences in visual preferences and cognitive load to further refine our understanding of enclosure perception and its effects on cognitive performance in professional settings.

While the current findings offer valuable insights into spatial perception within virtual environments, future research should explore more diverse office scenarios, including variations in organizational culture, team configurations, and real-world validation studies. These extensions would enhance the generalizability of the results and support the practical implementation of design recommendations in actual office settings.

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