Exploring an Architectural Framework for Human-Building Interaction via a Semi-Immersive Cross-Reality Methodology

Supplemental Material

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1 FIGURE DESCRIPTION

Detailed descriptions of Figure 4 and 6 in the main paper.

Figure 4

The deployment of the five conditions in the homes.

(a) The home of P1+P2 has an entrance that opens to a circulation zone (C1) that connects three adjacent functional zones to its right, in the sequential order: a bathroom (F1), a kitchen (F2) and an living area (F3) with a sofa and a dining table. At the end of the hallway is a bedroom (F4). This functional zone is adjacent to a semi-outdoor balcony (F5) to its right, whose door opens to the living area (F3). The bathroom (F1) and bedroom (F4) are enclosed spaces with doors opening to their inside, while the kitchen (F2) and the living area (F3) are open spaces connecting directly to the circulation zone (C1). There is a wall separating the kitchen (F2) and the living area (F3). All interior functional zones (bathroom, kitchen, living area, bedroom) have windows that open to the outside. This home has 7 conditions: 2 MF, 2 MC, 1 DFF and 2 DFC. In MF1, the wall stands parallel to the window of the living area F3, covering this window. In MF2, it forms a 40 degree angle at a corner of the living area F3, covering the door opening to the balcony F5. In MC1, it covers the entrance to the kitchen F2 from within the circulation zone C1, while being slightly rotated (10 degree) compared to the surrounding wall. In MC2, it stands perpendicular to the direction of the circulation zone C1, covering the entrance to the bedroom F4. In DFF, it stands at the boundary between the living area F3 and the balcony F5. In the DFC conditions, it disconnects the entrance from the circulation zone C1 to the kitchen F2 (DFC1) and the living area F3 (DFC2).

(b) The home of P4+P5 has an entrance that opens to a circulation zone (C1). This small hall has three doors: the front (D1) opens to a toilet (F1), the left (D2) opens to a bedroom (F2), and the right (D3) opens to the main space. This main space has 1 circulation zone (C2) and 5 functional zones. The circulation zone C2 connects to C1 through the door D3. To the right of C2 are two adjacent functional zones: a dining area with a dining table (F3) and a living area with a large sofa and the television (F4). To the left of C2 are two adjacent functional zones: a kitchen (F5) and an area to practice and perform music with a piano, bookshelves and a small sofa (F6). The dining area (F3), living area (F4), and music area (F6) form an open space that is accessible to a balcony (F7). The kitchen (F5) is an enclosed space with a door connecting to C2. This home has 7 conditions: 2 MF, 1 MC, 1 DFF, 2 DFC and 1 CFF. In MF1, the wall stands inside the dining area F3, parallel to the boundary between F3 and the

living area F4. In MF2, it stands inside the music area F6, behind the piano and perpendicular to a wall with a window. In MC, it forms a 30 degree angle within C1, to cover the entrances to the toilet F1 and the bedroom F2. In DFF, it stands at the boundary between the dining area F3 and living area F4, dividing them. In the DFC conditions, it disconnects the entrance from the circulation zone C2 to the living area F4 (DFC1) and the music area F6 (DFC2). In CFF, it is perpendicular to the boundary between the dining area F3 and living area F4.

Figure 6

Potential locations of the responsive wall to afford a Focus atmosphere in a prototypical floor plan.

The circulation zone C1 is a horizontal rectangle located at the bottom of the floor plan. The functional zones F1 (top-right) and F2 (top-left) are two adjacent vertical rectangles at the top of C1. There are two doors in the floor plan, one at the bottom-right (D1) and one at the bottom-left (D2), both opening to C1. The top wall of the floor plan has a window, which is inside the functional zone F2. There are a sofa and a television inside functional F1. The sofa is adjacent to the boundary between F1 and C1, while the television is on the opposite wall at the top of the floor plan, facing the sofa and door D1. The functional zone F2 has a working table and a chair. This table-chair set leans on the left wall of the floor plan, facing zone F1. Subsequently, door D2 is on the right side of the working table. In MF, the wall is inside F2, parallel to the left wall and right in front of the working table. In MC, the wall is inside C1, forming a 10 degree angle to disrupt the circulation between D1 and D2. In DFF, the wall is at the boundary between F1 and F2. In DFC, it is at the boundary between F2 and C1.

2 SUPPLEMENTAL DATA

Figure 1 visualizes the full questionnaire results of the five condition, and Table 1, 2, 3, 4, 5 show these results in numeric data. Table 6 shows the frequencies of how each architectural qualities and their affordances were mentioned in the semi-structured interview. Figure 2 shows the mean time that the participants spent in each conditions, categorized based on their behavior.

3 SUPPLEMENTAL FIGURES

Supplemental figures provide further visualization, such the virtual simulation of the homes (Figure 4), the UI (Figure 5), screenshots of the conditions (Figure 6), spatial zonings of the homes (Figure 7), and the deployment of the condition (Figure 8 to 13).

Figure 1: Questionnaire results of the conditions as stacked bar chart.

Table 1: Questionnaire result of condition MF (%)

	-3	-2	-1	0	1	2	3	
Light		12	38		31	19		Dark
Open			10	20	30	30	10	Closed
Cool				30	45	15	10	Warm
Cozy	10	10	15	40		20	5	Awestruck
Sociable				22	20	38	20	Private
Quiet	10	40	33	17				Lively
Expansive				30	11	49	10	Confined
Ambiguous	30	32	18	10			10	Understandable
Welcoming				31	39	20	10	Protecting

Table 2: Questionnaire result of condition MC (%)

	-3	-2	-1	0	1	2	3	
Light	12	10	34			10	33	Dark
Open	12	11	13	9	33	10	12	Closed
Cool			10	23	56	11		Warm
Cozy	9	35	23	33				Awestruck
Sociable		8	12	21	8	51		Private
Quiet		45	10	9	25		11	Lively
Expansive	9		13	10	34	23	11	Confined
Ambiguous			21	12	12	10	45	Understandable
Welcoming		23	9	13	31	24		Protecting

Table 3: Questionnaire result of condition DFF (%)

	-3	-2	-1	0	1	2	3	
Light		70	22		8			Dark
Open		10	20	11	9	50		Closed
Cool			22	28	41	9		Warm
Cozy		21	70		9			Awestruck
Sociable			22	18	33	27		Private
Quiet		39	31	20		10		Lively
Expansive		20		11	40	21	10	Confined
Ambiguous			9	11	12	60	8	Understandable
Welcoming		8	9	31	42	10		Protecting

Table 4: Questionnaire result of condition DFC (%)

	-3	-2	-1	0	1	2	3	
Light		43	11	12	24	10		Dark
Open		9	10	12	33	25	11	Closed
Cool		12	35	10	34	9		Warm
Cozy		12	30	25	33			Awestruck
Sociable			35	13	11	30	11	Private
Quiet		57	12	21	10			Lively
Expansive			24		20	56		Confined
Ambiguous		12	20		24	10	34	Understandable
Welcoming				20	22	58		Protecting

Table 5: Questionnaire result of condition CFF (%)

	-3	-2	-1	0	1	2	3	
Light		50	11	29	10			Dark
Open		18	22	10	50			Closed
Cool			27	53	20			Warm
Cozy		8	10	11	61		10	Awestruck
Sociable		11	60	20	9			Private
Quiet				28	52	20		Lively
Expansive			30	22	18	30		Confined
Ambiguous	9	11	22	20	30	8		Understandable
Welcoming		8	20	62		10		Protecting

Table 6: Frequency of verbal utterances of architectural qualities in the experiment and in each condition

Quality	Affordances	MF	MC	DFE	DFC	CFF
Functionality (28%)	Preventing existing activities	15 (8%)	9 (4.5%)	0	0	7 (3.5%)
	Supporting existing activities	26 (13%)	1 (0.5%)	5 (2.5%)	9 (4.5%)	11 (5.6%)
	Suggesting new activities to take place	13 (7%)	0	3 (1.5%)	5 (2.5%)	3 (1.5%)
Visuality	Covering available views	32 (16%)	7 (3.5%)	4 (2%)	8 (4%)	10 (5.1%)
	Creating directional views	7 (4%)	3 (1.5%)	0	4 (2%)	0
	Preventing unwanted views from outside	13 (7%)	3 (1.5%)	7 (3.5%)	0	1 (0.5%)
Connectivity (21%)	Disconnecting existing connections	20 (10%)	3 (1.5%)	4 (2%)	7 (3.5%)	6 (3%)
	Changing existing connections	16 (8%)	1 (0.5%)	7 (3.5%)	0	4 (2%)
	Opening new connections	6 (3%)	0	4 (2%)	0	1 (0.5%)
Materiality (15%)	Reflecting light	19 (10%)	4 (2%)	3 (1.5%)	5 (2.5%)	5 (2.5%)
	Increasing airflow	8 (4%)	2 (1%)	0	5 (2.5%)	0
	Reflecting sound	3 (2%)	3 (1.5%)	0	0	0
Uniformity (10%)	Separating zones into coherent spaces	11 (6%)	4 (2%)	0	6 (3%)	1 (0.5%)
	Hiding non-belonging elements	8 (4%)	4 (2%)	0	3 (1.5%)	0
Sum	198	198	44	37	52	42
	100%	100%	22.2%	18.7%	26.3%	21.2%

Figure 2: Mean time spent of the participants in five conditions (minute).

Figure 3: The participants experiencing the semi-immersive mixed reality simulation of their own homes. From left to right: participant P1, P3, P6 and P7.

Figure 4: The differences between the real homes of the participants and their abstracted virtual simulations, from left to right: the homes of Participants 3, Participant 4 and 5, and Participant 6.

Figure 5: From left to right: The UI that allows participant to control the wall, the questionnaire, and the questionnaire integrated inside the simulation window.

Figure 6: Three different conditions implemented in the Living zone of the homes of participant P4+P5, from left to right: MF, DFF, DFC.

Figure 7: The zoning of the homes of participant P1 and P2 (a), P3 (b), P4 and P5 (c), P6 (d), P7 (e) and P8 (f), showing the diversity of how the zones are configured, and the predominating quantity and area of functional zones compared to circulation zones.

Figure 8: The deployment of the five conditions in the homes of P1+P2.

Figure 9: The deployment of the five conditions in the homes of P3.

Figure 10: The deployment of the five conditions in the homes of P4+P5.

Figure 11: The deployment of the five conditions in the homes of P6.

Figure 12: The deployment of the five conditions in the homes of P7.

Figure 13: The deployment of the five conditions in the homes of P8.