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Interconnecting Stairs: The Vertical Axis Of Mobility and Social Interaction

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Agustin Chevez, as an architect and academic, has dedicated his career to discover the notion of work, and uncovering environments that best support our working lives. He is driven to understand how work has shaped our civilization and given purpose to our very existence. Chevez's interest in the relationship between people, space and technology saw him pursue a PhD on the evolution of workplace architecture. He has also contributed to workplace strategies in Australia, New Zealand and Singapore. Chevez is an honorary fellow at the Centre for Workplace Leadership, The University of Melbourne and an adjunct research fellow at the Centre for Design Innovation, Swinburne University.

Kirsti Simpson is an internationally recognized specialist in workplace design, who has earned a place on numerous boards—testament to an impressive career. She brings a style and flair to work environments that are also highly practical—places that balance function and innovation to ensure they're successful well into the future. Simpson is a great advocate and ally for her national and international clients, and one of her strengths is her ability to listen and think strategically to help them achieve their business goals. She is also an Adjunct Professor in the School of Architecture at the University of Queensland.

Abstract

Increasingly, atria with interconnecting stairs are being promoted to increase collaboration and the transfer of tacit knowledge across organizations. These claims are frequently supported with reference to the "Allen Curve" and the "bump factor." In addition, the importance of vertical mobility experience, as opposed to its mere functionality, is emphasized as a salient design consideration for interconnecting stairs. Empirical data for design effectiveness and organizational outcomes, however, is scarce. This study presents a multi-method empirical investigation into the role of interconnecting stairs in promoting vertical mobility and social interaction in an Australian firm. Findings moderate the expectations set upon stairs as the drivers of vertical mobility to that of enablers. The relative attraction of floors is proposed as the driver and structure of the vertical axis of collaboration and social interactions.

Keywords: Atria, Social Engineering, Stairs, Workplace Design

Background

Research on stairs in the workplace has predominantly examined their role in emergency evacuation (Huo et al. 2016; Ding, Zhang & Che 2017) and their contribution to health and well-being of employees (Meyer et al. 2010, Zhu et al. 2020). However, observations that the probability of two people communicating with each other declines rapidly as the distance between them increases, lead not only to the phenomenon known as the "Allen Curve" (1984), but to a greater reflection on the role that space and design elements, such as interconnecting stairs, have in enabling social interactions in the workplace.

The Vertical Axis of Collaboration

Sociological theories present strong arguments that removing spatial boundaries should increase collaboration and collective intelligence (Bernstein & Turban 2018). To this end, no other issue in the design of workplaces has received more attention than walls to connect, or buffer, workers from each other (Elsbach & Pratt 2007). For organizations distributed across multiple floors, such attention extends to spatial boundaries on the vertical axis: floors.

Visual and Physical Connectivity: Atria and Staircases

Labeled as a "place for space" (Shum 1990), an atrium opens up the floor plan, allowing for greater visibility of workspaces, colleagues, and ultimately, the organization (Marriage 2012). On its own, however, an atrium creates what Hillier and Hanson (1984) describe as the "visual-accessible paradox," in which a place might be visible, but not accessible. A staircase resolves this paradox by providing the missing physical connectivity (Ibid.).

This combined connectivity increases the ability to see and reach people across floors, leading to a higher "bump factor," a colloquial term used to describe the probability of bumping into someone, and it is cherished by knowledge-based organizations as the foundation of serendipitous encounters, leading to cross-pollination of ideas (Rodriguez 2017).

Design Considerations: From Trip to Journey

Increasing the accessibility of stairs in relation to elevators results in a higher stair usage ratio (Bassett et al. 2013). As a result, well-being certifications establish prescriptive guidelines on the location, visibility and visually appealing attributes of stairs (IWBI 2020). In terms of the latter, an atrium can greatly contribute to the "wide-open, brightly-lit, accessible staircases" qualities referred by Allen and Henn (2007).

Principles of experience design utilized to influence user behavior through usability, usefulness and desirability of interaction (Eyal 2014) are increasingly being adopted in the workplace (Rasila et al. 2009). Applying such principles to staircases aims to shift their purpose from moving people up and down, to creating journeys, in a similar way that the experience economy transitioned from selling services to selling experiences (Pine & Gilmore 1998).

The Need for Research

Forgoing profitable net lettable area for the empty space of an atrium with an interconnecting staircase is often justified by the paybacks that these bring to the organization, such as the previously discussed health benefits, increased collaboration and knowledge sharing (Gensler 2014, Bates Smart 2018). Importantly, however, the stairs need to be used for these benefits to occur.

The literature is abundant with attempts to increase employee engagement in stair-taking. These range from awarding points for taking the stairs that can be redeemed for merchandise (Schumacher et al. 2013), to "intelligent musical stairs," which produce sounds as people step on them (Peeters et al. 2013). The often unsustainable or temporary success of these strategies suggests that taking the stairs does not come naturally.

What is more, citing the Allen Curve, the bump factor and other sociological theories without empirical data on their effect on vertical collaboration is not only prone to inductive fallacies, but overlooks relevant research on walls. For example, Rashid et al. (2006) found that people avoid interacting with others in spaces with more visibility and accessibility. Bernstein and Turban (2018) also found that: "rather than prompting increasingly vibrant face-to-face collaboration, open architecture appeared to trigger a natural human response to socially withdraw from officemates and interact instead over email and [Instant Messaging]". Regarding the bump factor, Becker et al. (1983) found that informal interaction might be facilitated, not by unlimited opportunities for interpersonal contact, but by the opportunity for privacy.

In addition, statements such as "to create a community, start with stairs" (WeWork 2019) fail to notice that the spatial layout is insufficient to generate, sustain and increase interaction without the necessary changes in attitudes, programs and policies of an organization (Rashid et al. 2006). Thus, stairs might support a community, but not necessarily create one. To this end, the distinction between a "driver," referring to making things happen, and an "enabler," referring to making things possible, is important. As will be seen, stairs seem to play an enabling role.

Equally important is the need to consider underrepresented, but important factors regulating the use of floors. In the vertical transportation (VT) literature, the reason to go to another floor is referred to as the "relative attraction" of each floor (Strakosch & Caporale 2010). Simply put, some floors have more inter-floor traffic than others, due to the relationship between them. Interestingly, this is a negative factor in VT, because it affects the efficacy of the elevators when an organization occupies many floors and people travel between various divisions. This is the opposite of what would be desirable for interconnecting stairs.

Research Setting and Design

To study the relationship between workplace design and organizational performance a multi-disciplinary (design, engineering and management) and cross-sector (industry and academia), longitudinal study of a top-50 publicly-listed organization in Australia was undertaken. Data were collected on the organization's headquarters at three checkpoints in July 2016, October 2017 and August 2019, abbreviated as C1, C2, and C3, respectively.

The organization's headquarters were split into two buildings (A and B) to balance the leasing terms with the organization's growth. This strategy continued after the relocation, but with the buildings in closer proximity to each other (see Figure 1). Between C1 and C2, the organization implemented a redesign of its administrative structure, but the workplace remained unchanged. Between C2 and C3, the organization relocated to its new workplaces. Numbers "1" and "2" are used to indicate the pre-move and after-move buildings, respectively.

Building A2 features a prominent atrium with wide-open, brightly-lit, accessible interconnecting stairs, purposely designed to deliver the benefits of vertical mobility outlined in the background section. Building A1 also has a series of interconnecting staircases, but offers a lower-quality experience. Specifically, the staircases in building A1 lack openness and visual

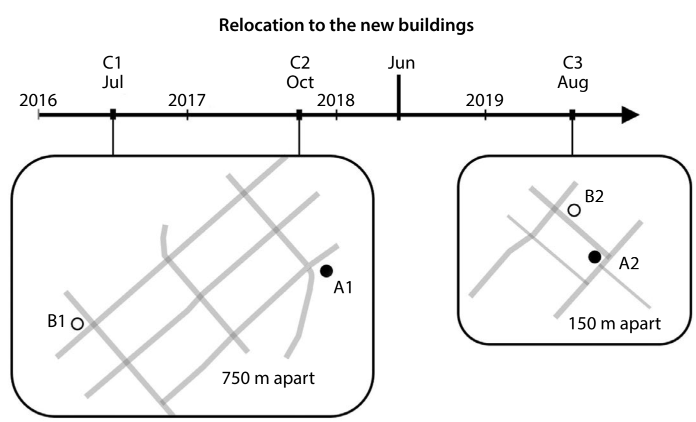

Figure 1. Research timeline, illustrating data collection checkpoints and relocation of headquarters. © Hassell

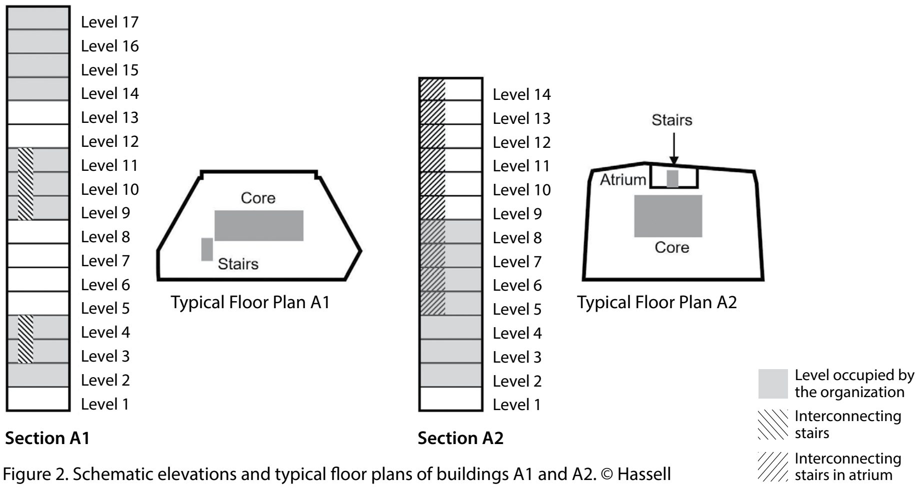

Figure 2. Schematic elevations and typical floor plans of buildings A1 and A2. © Hassell

Figure 3. Left: Interconnecting stairs in Building A1. Right: Atrium with interconnecting stairs in Building A2, showing the actual field of view of the time-lapse video. © Hassell

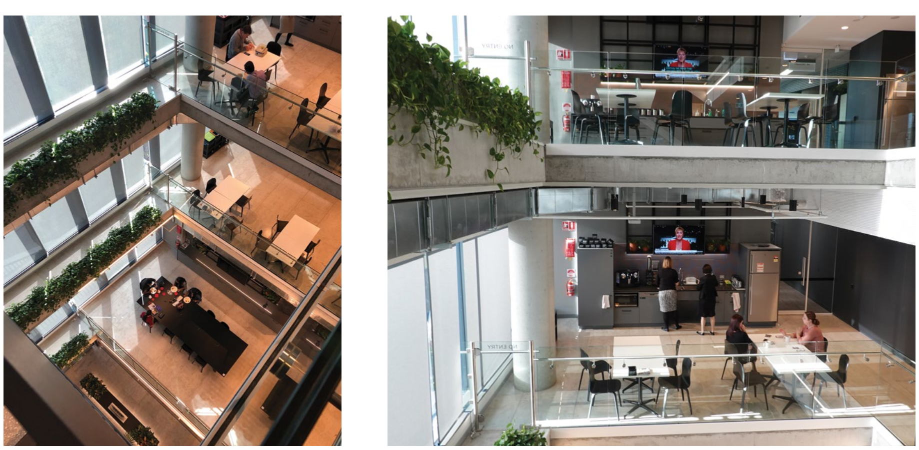

Figure 4. View from entry to staircase of Building A2, looking down from Level 9. Right: View from the staircase landing, Building A2, between levels 7 and 8. © Hassell

connectivity to other levels. Figures 2 and 3 depict the two designs.

The location of the staircase within the atrium and the type of spaces surrounding it aimed to maximize the visibility across floors. The atrium itself is surrounded by an open kitchen with lunch tables on one side (see Figure 4), and a variety of informal collaboration spaces with various sitting and standing options on the opposite side.

Data Collection and Analysis

The study involved collection of quantitative and qualitative data, specifically the following:

1. *Time-lapse video footage.* A wide-angle camera was fixed to a handrail on Level 9 pointing down the atrium of building A2. This provided a complete view of the atrium staircase down to Level 5, as shown in Figure 3. Pictures were taken between 11:00 am and 3:15 pm, at a rate of one picture per second. The time period was chosen to include the lunch period, during which employees move to a large kitchen/eating area on floor 5, or small kitchen/eating areas located on floors 6–9. The 4 hours and 15 minutes covered resulted in a time-lapse video of 5 minutes and 39 seconds. The video footage was analyzed frame-by-frame to quantify a) the number of people per trip, b) the level where they entered, and c) the level where they exited the stairs. The direction of the trip was inferred from b and c.
2. *Workplace performance survey.* Leesman's workplace performance survey was used to collect data on work activities and perceived support for these activities; employees' sense of productivity, pride, enjoyment, culture and community; employee mobility; and satisfaction with physical and service features.
3. *Social Network Analysis (SNA):* Data on employees' professional network ties and the content of these ties (information exchange, problem-solving, idea generation, reviews/approvals, and social interactions) was collected via an online survey developed by Optimice and the research team.

Data Collection Checkpoint	Margin of Error at 95% Confidence	Population	Social Network Analysis Sample Size* (No.)	Social Network Analysis Sample Size* (%)	Workplace Performance Survey Sample Size (No.)	Workplace Performance Survey Sample Size (%)
C1	+/- 3.02%	1,203	666	55	561	47
C2	+/- 4.08%	1,065	491	46	374	35
C3	+/- 5.13%	853	269	32	256	30

** Based on Costenbader and Valente (2003), the Social Network n-degree resulted in a minimum of 0.8 average correlation.*

Table 1. Data collected at three checkpoints during the research, as shown in the timeline in Figure 1.

4. *Ethnographic observations:* Unobtrusive workplace observations were undertaken to document interactions between people, people and objects, and people and information (e.g., computer monitors, paper, whiteboards, etc.) Observations at random intervals were done in parallel to the time-lapse video.
5. *Face-to-face interviews:* Employees were randomly selected for a voluntary, semi-structured interview to increase the richness of the data and help contextualize the results from other methods. Questions aimed to better understand employees' routines throughout the day, providing the opportunity to know what worked, and what did not, in greater detail than was afforded by the survey.
6. *Real-time occupancy data:* The organization's Serraview space utilization monitoring system provided detailed reports of the number of people who were connected to the organization's network via WiFi or cable. These figures were used to calculate occupancy. Population and sample details for both surveys (methods 2 and 3) are as shown in Table 1.

	Down Frequency (%)	Up Frequency (%)
Breakdown by direction (% out of 183 trips)	110 (60%)	73 (40%)
Breakdown by size of group (% out of 110 and 73, respectively)	374	35
Single	95 (86%)	63 (86%)
Two people	14 (13%)	9 (12%)
Three people	1 (1%)	1 (1%)

Table 2. Frequency and (percentage) of trips in building A2 atrium, by direction of travel and size of group.

No. of Flights at a Time	Number of Trips	Duration per Trip (sec)	Total (sec)
1	8 + 7 + 7 + 14 = 36	20	720
2	25	40	1,000
3	8 + 1 = 9	60	540
4	3	80	240
Total	**73**	**N/A**	**2,500**

Table 3. Estimated total time for trips going up, based on Figure 5.

No. of Flights at a Time	Number of Trips	Duration per Trip (sec)	Total (sec)
1	15 + 13 + 7 + 9 = 44	15	660
2	4 + 4 + 34 = 42	30	1,260
3	1 + 11 = 12	45	540
4	12	60	720
Total	**110**	**N/A**	**3,180**

Table 4. Estimated total time for trips going down, based on Figure 5.

Results

Frequency of Trips

A total of 183 trips were observed during the 4-hour, 15-minute recorded period of the staircase of building A2. The majority of these, 60 percent, were to lower levels. Most trips, 86 percent, were done by a single person, both up and down (see Table 2).

While a comprehensive time utilization study (TUS) of the stairs cannot be conducted based on the time-lapse video, the footage allows for useful estimations. Using the method outlined below, the analysis shows that at least one person was traveling, up or down, for 37 percent of the time recorded.

An estimated average time of 15 seconds per floor for trips going down and 20 seconds for trips going up is used. Tables 3 and 4 show the calculations used to estimate the total travel time of observed trips going up and down, respectively. The estimation is likely to tilt towards an over-estimation of the utilization of the stairs, because the time-lapse video was recorded during higher occupancy periods, avoiding the usually lower occupancies in the early morning and late afternoon; and, some of these trips occurred concurrently, whereas the calculations assume all trips as discrete. The complexities of separating concurrent and discrete trips are not justified. To contextualize this figure, 63 percent of workstations on one of the typical floors (Level 8) had a lower utilization than the stairs.

Number of consecutive floors traveled	Up frequency	Down frequency	Total up and down
1	36 (49%)	44 (40%)	80 (44%)
2	25 (34%)	42 (38%)	67 (37%)
3	9 (12%)	12 (11%)	21 (11%)
4	3 (4%)	12 (11%)	15 (8%)
Total	**73 (100%)**	**110 (100%)**	**183 (100%)**

Table 5. Frequency of trips, by number of consecutive floors traveled.

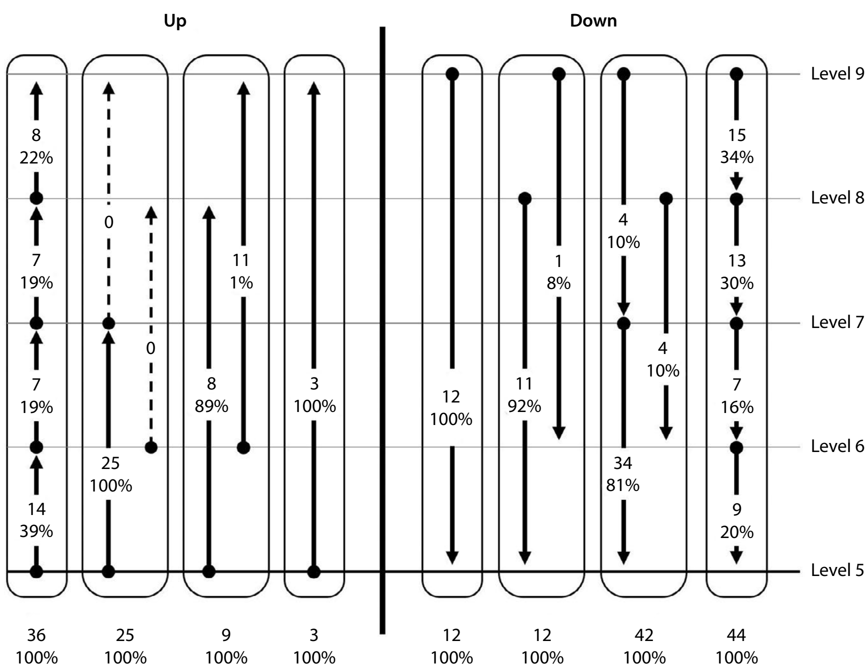

Figure 5. Frequency of trips by number of floors covered in a single run, in both directions.

These utilization rates support initiatives of space optimization pursued by TUS to make the space more efficient, but not necessarily more effective. While these are not mutually exclusive, they are unrelated. In this sense, a TUS on its own is blind to the quality of interactions.

Direct observations undertaken in parallel to the time-lapse video support the relevance of studying the qualitative component of trips. The difference between studying stairs for the purpose of vertical mobility, and studying them as social connectors, was highlighted by observations illustrating the stereotypical interactions described, to promote the use of stairs to increase the "bump factor."

For example, parameters such as gender and age, which are widely cited in the egress literature as factors influencing speed of travel (Choi, Galea & Hong 2014), were less relevant in our observations. It was notable that the travel time of a group would be dictated by the anticipated time required to convey the message and the remaining number of steps. This was clearer when there was a mutual, seemingly unspoken, assumption that the individuals would split ways at the end of the trip. When running out of stairs, they would stop on the landing. In contrast, groups of up to three people were seen traveling at, a speed similar to that of a single person, when making use of the stair for its utilitarian purpose of going to another floor, without any interaction between them.

Another factor influencing the speed of travel was the extent of interaction between the person traveling and the objects they were carrying. Interactions with smartphones, paperwork and even open laptops would slow, or even temporarily stop a trip.

Although not measured in this study, Shah et al. (2011) have identified shorter travel times when taking the stairs instead of the lift, which they argue, could translate into a potential increase in productivity and fitness.

- *Factors moderating the frequency of trips.* The frequency of trips, in both directions, decreased with the number of consecutive floors traveled (see Table 5). Overall, people were more likely to travel between adjacent floors. A breakdown of these trips is illustrated in Figure 5.

- *Frequency of two-way trips as a function of population and floor adjacency.* Numerous parameters contribute to the requirements of VT in office buildings (Strakosch & Caporale 2010). Importantly, they can be simplified to a function of the population: more people equals more trips. This logic can be used to test if the number of two-way, interfloor trips correlates to the floors' combined population.

To implement this test, the two adjacent floors with the highest frequency of trips were identified, and their minimum occupancy calculated. These were levels 8 and 9, with a combined total of 23 trips. As per Figure 6, the minimum average of people, during the time of observation, on levels 8 and 9 was 44, and 39, respectively.

Based on the above, a minimum of 83 people produced the maximum number of 23 trips between adjacent floors. Following the same process, an estimated minimum of 89 people on levels 7 and 8 produced 20 trips. That is, contrary to expectations, more people (89>83) engaged in fewer trips (20<23). While the difference is small, the analysis below further challenges a correlation between population and frequency of interfloor trips.

The highest frequency of trips, 59 (more than double the frequency of trips between the most populous floors, 8 and 9), did not occur between adjacent floors, but between levels 5 and 7, despite their low combined occupancy. The minimum average occupancy of Level 7 was 45 people. Level 5, an atypical floor, has no workstations (thus no population on its own), but instead hosts a variety of closed meeting rooms, a well-being center, a central café, and a "Town Hall" space.

As discussed below, having a reason to move vertically had a higher influence than the relative population differences between floors.

Work-Related and Non-Work-Related Motivations for Vertical Mobility

Quality data provides further insight regarding floor attractiveness as a driver of vertical mobility. Interviews with employees from Level 7 revealed that due to their type of work (legal counsel) they required a higher level of confidentiality in their meetings than the privacy offered by the open and semi-open meeting spaces provided on their floor. As a result, they utilized the various enclosed meeting rooms on Level 5. Interviews with employees from multiple levels revealed substantial disagreement regarding the desirability of closed meeting spaces, and the benefits and drawbacks of private meetings for organizational effectiveness. The need for enclosed meeting rooms was expressed by employees from multiple floors, but never more frequently or more passionately than by employees from Level 7. This articulated need for specific facilities can partially account for the atypical frequency of trips observed between levels 5 and 7.

Likewise, in interviews, employees from Level 9 pointed out the lack of microwave ovens in the kitchen/eating areas on their floor. This can partially explain the frequency of trips between levels 8 and 9, as Level 9 occupants used the atrium staircase to reach the Level 8 kitchen to reheat meals.

This is important because it moderates the expectation set on stairs as the drivers of trips—provide them and they will be used. If this maxim were true, a stronger positive relationship between the frequency of trips and population would have been observed. Instead, results position the staircase as the enabler of trips created by the "relative attraction" of each floor (e.g., access to meeting rooms or microwaves).

Importance, Satisfaction, Pride and Productivity

In the workplace performance survey, participants ranked 25 physical features of their workplace by relative importance. Chair, desk, temperature control, and meeting rooms were consistently ranked within the top five items across C1, C2, and C3. Whereas, the atrium ranked 21st across the three checkpoints. However, the atrium's percentage of satisfaction in C2 was 11 percent, whereas in C3, it was 74 percent. Indeed, the atrium reported the second-highest improvement in satisfaction between C2 and C3—just below plants and greenery, of which building A1 had none. This suggests the atrium effected a substantial improvement in the perceived experience of vertical mobility.

Additionally, pride in the workplace saw a significant improvement, from 44 to 66 percent, from C2 to C3. Even the perception of workplace image increased from 43 to 69 percent during that interval. While improvements may result from a combination of workplace factors, the considerable increase in satisfaction with the atrium and its presence in the workplace could be a contributing factor. Self-reported productivity did not change between C2 and C3.

These sets of results suggest that, an atrium, even when not regarded as highly important by a building's occupants, doesn't go unnoticed, and could potentially contribute to boost indicators such as pride.

Impact on Interactions Across Floors

Table 6 shows the percentage of interactions in building A1 from one floor (row) to another (column) at C2, as per the network survey data. For example, 64 percent of the interactions on Level 15 were restricted to that floor alone; only

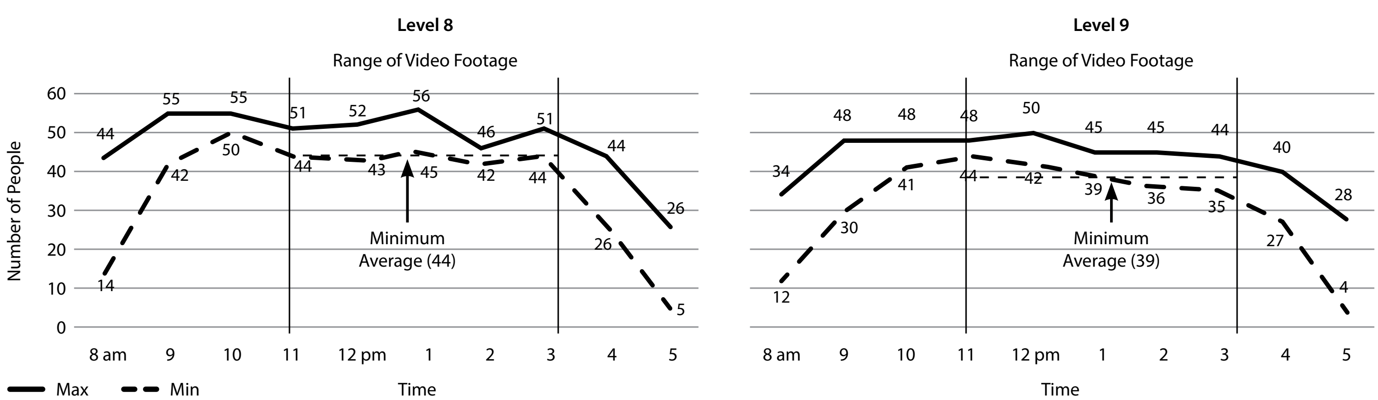

Figure 6. Maximum, minimum, and average minimum occupancy of levels 8 and 9 during the time-lapse period.

eight percent were with Level 14 Conditional formatting is used to highlight the higher percentage of interactions.

The data reveals that most interactions occur within the same floor. This "silo effect" by floor confirms prior research (Allen & Henn 2007). Based on the same network data from period C3 for building A2, Table 7 shows a similar pattern of interactions occurring primarily within the same floor. Comparing the interaction percentages between C2 and C3 reveals that interactions across floors did not increase in Building A2.

Further analysis of the network data shows that the division of functions into departments and their vertical stacking in the building have an important effect on fostering, or hindering, the reasons to move vertically. In particular, the location of opinion leaders (people with a high number of important network ties) on a given level could potentially enhance that level's "relative attraction", might increase cross-level interactions in the network data, and may manifest in an increase in vertical mobility. Analogous to the effect of the microwave ovens on Level 8 that attracted employees from Level 9, opinion leaders could be thought of as "human microwaves", who present a persuasive professional motivation for people to move vertically.

Contributions and Limitations

The study's findings present initial validation that examining the effect of vertical mobility for organizational processes and outcomes requires different methods than those used for egress or health and well-being (Warren 2008). Conceptually, the meaning and usefulness of a material artifact such as an atrium or a set of interconnecting stairs is not fully determined by its physical properties. Instead, it emerges through people's interaction with the artifact (Orlikowski & Scott 2008). Cultural baggage that people bring with them to make sense of the artifact often critically shapes that interaction. An employee from one company may see an atrium as a useful and normatively accepted opportunity to network and exchange tacit knowledge; an employee from another company may regard being seen in the atrium as a socially undesirable signal of not working at their desk, and not creating value for the company.

The multi-method approach presented attempts to capture some aspects of these contextual and cultural influences. A more thorough examination of organizational cultural influences on vertical mobility was outside the scope of the present study, but would have aided the interpretation of results.

The limitations of the present study point to opportunities for future research. The single case study design may not be generalizable to other contexts. It is also acknowledged that unavailability of elevator log data prevented an assessment of the distribution of vertical mobility between stairs and elevators. Lastly, given the prominence of organizational context as a likely determinant of observed vertical mobility patterns, and of the effects of such mobility on social interactions, the authors encourage studies that examine enablers and organizational consequences of vertical mobility across different organizations and settings.

	L 17	L 16	L 15	L 14	L 11	L 10	L 9	L 4	L 3	To B_1	Total	n
L 17	29%	5%	10%	10%	10%	2%	0%	0%	3%	27%	100%	58
L 16	2%	59%	2%	5%	7%	3%	4%	5%	0%	13%	100%	255
L 15	3%	1%	64%	8%	4%	1%	2%	6%	1%	9%	100%	177
L 14	4%	6%	8%	45%	10%	2%	4%	4%	5%	14%	100%	197
L 11	1%	4%	4%	5%	59%	7%	7%	3%	2%	9%	100%	351
L 10	1%	2%	1%	0%	12%	62%	9%	3%	2%	7%	100%	322
L 9	0%	1%	2%	0%	5%	9%	70%	1%	0%	10%	100%	369
L 4	1%	4%	4%	4%	4%	4%	2%	63%	5%	8%	100%	419
L 3	1%	1%	4%	2%	3%	3%	0%	7%	72%	6%	100%	215

Table 6. Percentage of interactions by floor in Building A1 at C2.

Conclusions

The study's key results suggest that the expectation set upon stairs as drivers of mobility and social interaction may have to be moderated. In this study, improvements of the experience of vertical mobility technologies did not result in improved cross-level interactions. Instead, findings point towards the relative attractiveness of floors, as determined by occupants' work-related and non-work-related needs, as a determinant for vertical mobility. ■

Unless otherwise noted, all image credits in this paper are to the authors.

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	L 9	L 8	L 7	L 6	L 5	L 4	L 3	To B_2	Total	Freq.
L 9*	74%	1%	3%	1%	-	3%	3%	15%	100%	156
L 8*	2%	81%	9%	0%	-	3%	1%	3%	100%	124
L 7*	3%	4%	76%	5%	-	1%	1%	6%	100%	139
L 6*	1%	3%	1%	92%	-	0%	1%	1%	100%	96
L 5*	-	-	-	-	-	-	-			
L 4	3%	2%	2%	0%	-	72%	13%	7%	100%	165
L 3	3%	1%	1%	0%	-	9%	80%	5%	100%	214

** indicates floor serviced by interconnecting stair*

Table 7. Percentage of interactions by floor in Building A2 at C3.

"If the maxim 'provide stairs, and they will be used' were true, a stronger positive relationship between the frequency of trips and population would have been observed."

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