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ABSTRACT

Although it is recognised that face-to-face interactions are important for sharing interests and (new) knowledge, it remains unknown how and where students and university employees interact in academic buildings. Therefore, the aim of this study is to analyse the location choice for face-to-face interactions in an academic building, including several personal- and interaction characteristics. An Experience Sampling Method (ESM) was used to collect data on 643 face-to-face interactions during two weeks in the Flux building at Eindhoven University of Technology, the Netherlands. In general, students more often interacted in meeting rooms than teaching staff, and support staff interacted less in eat/drink areas and the hallways than other users. Unexpectedly, some of the lectures took place outside of traditional project-/lecture space. Real estate managers of university campuses could use these results to create better interactive work environments that stimulate face-to-face interactions among employees and students of different departments.

Practitioner Summary: Based on longitudinal data of ftf interactions among students and employees in an academic building, results showed that ftf interaction characteristics, compared to personal characteristics, are most important for explaining the location choice of interactions. These insights could help to design academic work environments that optimise the support of interactions.

Abbreviation: ABO: activity-based office; ANOVA: analyses of variance; ESM: experience sampling method; FTF: face-to-face; HR: human resources; MMNL: mixed multinomial logit model; NewWoW: new ways of working

Introduction

The economy is changing from an industrial economy to a knowledge-based economy, which causes employees and their knowledge to be the most important strategic resource for organisations. Therefore, interaction and communication have become essential in knowledge-driven organisations, such as academic organisations (Heinzen et al. 2018). Employees have to talk and interact with each other to obtain a maximum amount of knowledge creation in the organisation (Marouf 2007). Additionally, interpersonal relationships at work are important for enhancing job performance (Wilson 2018), promoting employee flourishing (Colbert et al. 2016) and innovative behaviour (Scott and Bruce 1994; Dul and Ceylan 2011). Also, social support at the workplace is important for employees' wellbeing (Collins,

Hislop, and Cartwright 2016). In addition, a reduced number of face-to-face (ftf) interactions can cause problems such as social isolation (Baruch 2000; Mann and Holdsworth 2003). The design of offices has been shown to play a key role in the frequency and nature of ftf interactions at work (e.g., Peponis et al. 2007; Davis, Leach, and Clegg 2011; Hua et al. 2011), which eventually could strengthen an organisation's innovation capacity (Dul and Ceylan 2011). Therefore, many organisations are rethinking their office design to stimulate ftf interactions among employees.

New communication tools have encouraged many organisations to choose for the so-called New Ways of Working (NewWoW) principle (Bijl 2007) when doing so. NewWoW can be seen as a collective name for new work concepts and management principles,

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which are characterised by independency, time and space flexibility and mutual trust between the manager and the employee (Peters et al. 2011). The accompanying office innovations to support NewWoW include the activity-based office (ABO) concept. An ABO concept can be described as an office where people 'can choose an activity-based workstation that best suits the activity at hand from a functional perspective, which also matches the employee's preferences' (Appel-Meulenbroek, Groenen, and Janssen 2011). In ABO's, interactions can take place in many different types of areas, whenever you want, but are expected to more often be online, from home or during travelling. However, it remains essential that people regularly come to the office for ftf meetings and workplace managers could benefit from more insight on how to make the office the best suitable place for specific types of interactions.

A lot of research has been done in regular office buildings about where interactions take place and which elements of the office layout can stimulate interaction. However, the NewWoW and ABO concept is also being implemented in more and more academic office buildings, because of changing space demands (e.g. increased collaborative and interdisciplinary research activities, knowledge exchange between industry and academia, attracting and retaining talented people), new information and communication technologies, financial pressure, carbon reduction commitments and workplace design trends in other sectors (Pinder et al. 2009). Additionally, it is the hope that such academic buildings would stimulate ftf interactions across staff and students both within and between departments (Gorgievski et al. 2010). But little research has been done on ftf meetings in academic buildings, especially about which factors impact the location type choice for interactions of students and staff of different departments. These buildings are different from regular offices due to teaching and student facilities. This paper addresses this gap in research by studying the location choice for ftf interactions at the scale of an academic building, also analysing the influence of several personal characteristics (e.g. age, gender and personality), work-related characteristics (e.g. role in the organisation, department, student/employee) and interaction characteristics (e.g. type, activity, intentionality) on the location choice.

Besides the holistic approach with many variables and the research setting of an academic building, the main contribution of this research to previous studies is that real-time longitudinal data on ftf interactions were collected using an Experience Sampling Method (ESM), which is still limited in workplace research. Data were collected at three random times a day for 10 workdays, among 92 users of the academic building Flux at the campus of Eindhoven University of Technology in the Netherlands, which resulted in a sample of 643 ftf interactions. For the analyses, state-of-the-art discrete choice modelling, namely a mixed multinomial logit model (MMNL), approach was used to analyse all expected relationships between the location choice in an academic building and personal- and interaction characteristics simultaneously in a single model.

The remainder of this paper is structured as follows. First, based on an extensive literature review, expected relationships are identified between ftf interactions, personal- and work-related characteristics and the location choice. Next, the data collection procedure, sample and methodology are described, followed by the discussion of the main results. The final section ends with the conclusion, limitations and recommendations for future work.

Theory

An increased number of higher education institutions use an ABO concept (e.g., Pinder et al. 2009). Previous studies on higher education facilities where employees moved from traditional office concepts to more open plan offices and flexible working concepts, showed that people are satisfied about the opportunities for meeting other people, the design, functionality and comfort of the new work environment, but on the other hand complain about the decreased personal control of the work environment, concentration, privacy and personal- and collective storage space (Parkin et al. 2006; Van der Voordt and Van der Klooster, 2008; Gorgievski et al. 2010). These findings are similar to such studies in regular ABOs (Engelen et al. 2019), although contradictions between studies are not uncommon. For example, Rolfö, Eklund, and Jahncke (2018) found a perceived decrease of communication within teams, due to the high people-to-workstation ratio of the ABO concept. On the other hand, Wohlers and Hertel (2017) suggested that the openness of the main work environment could increase relationships and new collaborations between non-team colleagues. In addition, Stryker, Santoro and Farris (2012) found, comparing low-visibility and high visibility environments of high-tech teams, that the type of workspace (open, low-walled workspaces) stimulates face-to-face interaction in low-visibility work environments and is

Table 1. Important locations for face-to-face interactions in office buildings.

	References					
Location types	Boutellier et al. (2008)	Rothe, Gersberg and Nenonen (2007)	Rashid, Wineman and Zimring (2009)	Staplehurst and Ragsdell (2010)	Hua et al. (2011)	Appel-Meulenbroek, De Vries, and Weggeman (2017)
Workspace		X	X	X	X	X
Meeting room			X	X	X	X
Lecture room		X				
Coffee corner	X				X	X
Café/restaurant		X				
Hallway	X		X			X
Elevator	X					
Space for copying, printing etc.	X					
Project-/creative space		X				X
Lounge area		X				
Informal-/social meeting space		X			X	

mediated by ftf interaction opportunities (i.e., the total number of spaces where face-to-face interaction can occur within a 25 m radius of the workspace).

Overall, it is thus expected that academic buildings that implemented flexible office concepts would stimulate more ftf interactions across staff and students both within and between departments.

Ftf interactions

An interaction can be described as 'a process by which people act and react to those around them' (e.g., Gerdenitsch et al. 2016, 2). To the best of our knowledge, research on ftf interaction patterns in academic buildings is limited. Most studies focus on regular office buildings. As can be seen in Table 1, these studies identified several important locations where interactions might take place. For example, Hua et al. (2011) showed that workstations, coffee areas, and open/closed meeting areas are importation locations for ftf interactions. A café/canteen is an important location for sharing personal information (Davenport and Bruce 2002; Rothe et al. 2012) . Previous studies have shown that most interactions take place near or at the workspace (e.g., Rashid, Kampschroer, Wineman, and Zimring 2006; Rothe et al. 2012).

Two types of interactions at work can be defined, namely work-related interactions and social interactions, which are informal interactions (e.g., a chat) during for example coffee breaks, lunches and dinners (e.g., Marouf, 2007; Weijs-Perrée, Appel-Meulenbroek and Arentze 2018). As specific locations in ABOs are intended to support specific types of interactions, we formulate the following first hypothesis:

Hypothesis 1 (H1): Social ftf interactions take place at different locations in academic buildings than work-related ftf interactions

Allen and Henn (2007) distinguished three types of communication activities within an organisation, namely communication for coordination, information and inspiration. Previous studies suggested that the more informal inspiration activities, such as casual conversations (i.e., social interactions/activities) take place more often at individual workstations, kitchen or coffee areas, in a café or in the hallways (e.g., Davenport and Bruce 2002; Tschan, Semmer and Inversin 2004; Hua et al. 2011). Other inspiration activities, which are highly important in an academic setting, such as discussions and brainstorming are more likely to take place at meeting rooms or at peoples' workspace (e.g., Tschan, Semmer and Inversin 2004; Staplehurst and Ragsdell 2010). In addition, activities, related to coordination and information (i.e., formal planned meeting), are likely to take place in meeting rooms or at people workplace (e.g., Staplehurst & Ragsdell 2010). Therefore, the following hypothesis is formulated:

Hypothesis 2 (H2): The location choice for ftf interactions differs for different activities (e.g. catch up/chat, discussion or brainstorming)

With regard to the duration of a ftf interaction, Boutellier, Ullman, Schreiber, and Naef (2008) found a difference in duration of ftf interactions comparing a cellular office and a multi space office. In addition, Weijs-Perrée, Appel-Meulenbroek and Arentze (2018) showed that ftf interactions (in business centres) at a restaurant/café/canteen are mostly of a longer duration compared to locations for chats/catch ups (e.g. hallway or coffee corner). Therefore, it is expected that

interactions with different durations also will take place at different locations in academic buildings.

> **Hypothesis 3 (H3):** Ftf interactions with a longer duration take place at different locations in academic buildings than ftf interactions with a shorter duration

Furthermore, previous studies showed that the design or layout of the physical work environment mainly facilitates unplanned ftf interactions (Peponis et al. 2007; Toker and Gray 2008). The intentionality of ftf interactions could therefore also be relevant for the location type choice in academic office buildings. This brings us to the following hypothesis:

> **Hypothesis 3 (H3):** Ftf interactions with different intentions (i.e. pre-planned, intentionally unscheduled, or coincidental) take place at different locations in academic buildings

Personal characteristics

It is recognised that personal characteristics could influence interaction patterns as well. For example, Zengyu et al. (2013) analysed the influence of demographic factors on the usage of advice-seeking networks. Findings of their study suggest that women are more likely to use personal networks than men. Rothe et al. (2012) and Yildirim, Akalin-Baskaya, and Celebi (2007) found differences between men and women regarding their work environment preferences. In addition, Pangil and Nadurdin (2008) suggested that men more often discuss their work during an interaction than women. Another study on noise disturbance found that women felt more disturbed by noise in open-plan office than men (Kaarlela-Tuomaala et al. 2009). Based on the gender differences described by previous studies, the following hypothesis is proposed:

> **Hypothesis 5 (H5):** Women choose different locations for ftf interactions compared to men.

With regard to age differences, the results are more conflicting. Bontekoning (2007) found that generation X (born between 1965 and 1977) does not like traditional long meetings in 'boring' meeting rooms, but prefer social 'to the point' interactions in stimulating work environments. Puybaraud et al. (2010) suggested that Generation Y (born after 1977) prioritises collaboration and interaction at the work environment, which could be facilitated through team spaces and break out spaces. Rothe et al. (2012) suggested that younger workers prefer more social facilities such as restaurants and bars in the office than older people, and thus are more likely to interact at these facilities/locations. On the other hand, Haynes, Suckley and Nunnington (2017) found that older employees are more positive about interaction at work at refreshment areas, canteen or around the printer/copying area, compared to younger employees. Therefore, the following hypothesis is formulated:

> **Hypothesis 6 (H6):** The location choice for ftf interactions differs among people from different age groups.

Previous studies in regular office buildings, also, showed a relationship between personality and office use with regard to ftf interactions. For example, Oseland (2013) found that artistic and creative personalities prefer informal spaces to interact, whereas close-minded people prefer formal spaces to interact. This brings us to the following hypothesis:

> **Hypothesis 7 (H7):** The location choice for ftf interactions differs among people with different personalities.

With regard to role within the organisation, Zahn (1991) found that people with similar roles are found to use the same spaces more often. Another study showed that people who have a higher job position in an organisation are more likely to use a fixed workspace (Göçer et al. 2018). Thus, probably people from the same department, with the same job position and people from the same user group (i.e., students or employees) are also more likely to use the same spaces for their ftf interactions.

> **Hypothesis 8 (H8):** The location choice for ftf interactions differs among people with different roles (i.e. user group, department and job position) within an (academic) organization.

Contact person(s) characteristics

With regard to contact person(s) characteristics, Tschan, Semmer and Inversin (2004) found that people who are more familiar with each other are more likely to interact with each other than people less familiar with each other. This is also recognised by other studies on ftf interaction in offices, which showed that people from the same group (e.g., same department) are more likely to interact (i.e., homophily) (Wineman, Kabo, and Davis 2009; Kabo 2017). On the other hand, weak ties could provide access to more new information and resources compared to strong ties (Granovetter 1973). Thus, it is possible that ftf interactions between people from different backgrounds (e.g., department and user group) also take place at different locations than those between people from
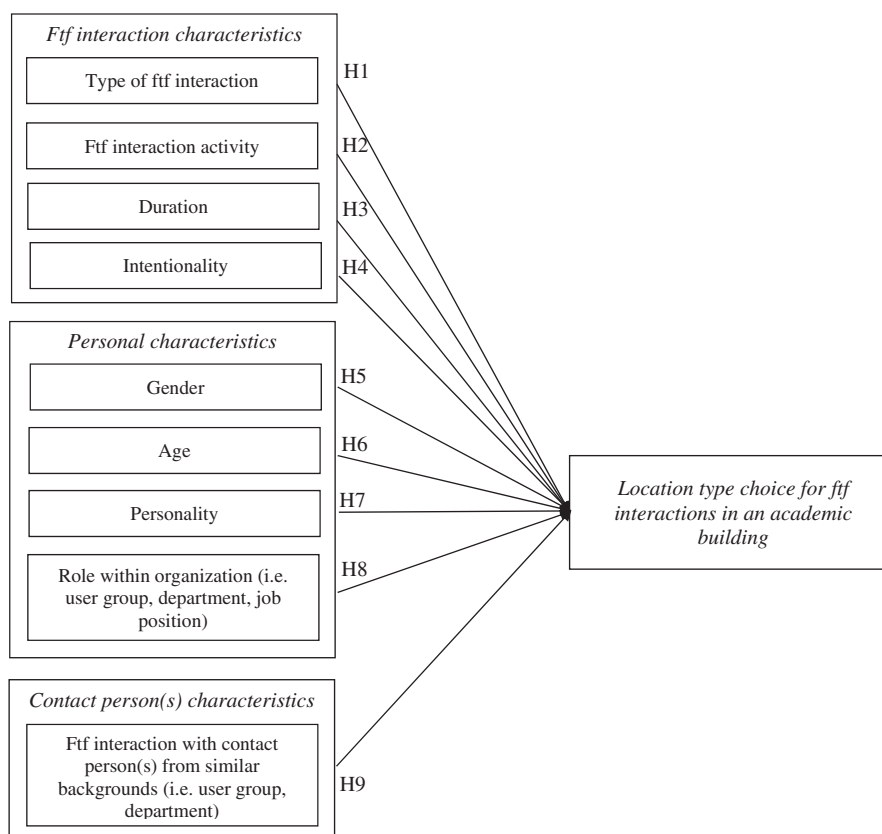
Figure 1. Conceptual model: factors influencing the location choice for a ftf interaction in an academic building.

similar backgrounds. Therefore, the following hypothesis is proposed:

> **Hypothesis 9 (H9):** Ftf interactions between people from different departments and/or user groups are likely to take place at different locations than ftf interactions between people from the same department and/or user group

To summarise, personal characteristics (e.g., age, gender, work-related characteristics and personality), ftf interaction characteristics (e.g., intentionality, business/social interaction, interaction activity) and contact person(s) characteristics (e.g., similar/different user groups or departments) are assumed to influence the location type choice for ftf interactions in academic buildings (see Figure 1).

Materials and methods

To test the conceptual model, a case study is performed in the Flux building, a relatively new building of the TU/e campus in the Netherlands. Flux is the new accommodation for two university departments, namely Electrical Engineering and Applied Physics. Employees and students of the Department of Electrical Engineering focus on studying, designing,

realising and testing novel electrical/optical components and the Department of Applied Physics focus on three disciplines, namely on fluids, bio and soft matter; plasmas and beams; and nano, quantum and photonics. These departments use the labs, teaching labs, offices, lecture rooms that are situated in the Flux building. The building is 26.000 m^2 and has 11 floors. It provides accommodation for around 800 employees and 1.350 students, which makes it a total of approximately 2.150 users. As the building is publicly accessible, people from other departments can also use it.

The ground floor of the building accommodates a supermarket, a reception, some meeting spaces and some shared closed offices. The first floor mainly consists of lecture spaces and open study space, whereas the second, third and fifth floor consist of shared closed offices, small open offices and open study spaces. The project spaces (i.e., the labs) are located on the fourth, eighth and tenth floor. The sixth floor contains multiple facilities such as a canteen, colloquium spaces and meeting spaces. Last, floor 7 and floor 9 consist of closed offices of different sizes and open workplaces for graduates. See Supplemental Appendices A–K for the floorplans of the Flux building, to get more insight about the placement of locations.

The users of Flux were approached by email to participate in a 2-step study, starting with a questionnaire on the users' characteristics, followed by an ESM questionnaire to collect longitudinal data (i.e. repeated observations at multiple points in time) of user's ftf interactions patterns. It is recognised that ESM is a useful method to analyse interpersonal ftf interactions and to obtain a representative sample of individuals' behaviour (e.g., Fisher and To 2012; Uy, Foo, and Aguinis 2010). This method is less influenced by memory biases as participants have to report their experiences immediately after a certain signal, compared to traditional diaries (Scollon, Kim-Prieto, and Diener 2003). The signal contingent ESM method was used (see Reis and Gable 2000). The main advantage of this method is that it can immediately capture a random sample of ftf interactions, with a minimal memory error (Fisher and To 2012). Respondents received a prompt (i.e., text message and/or e-mail) at three random times a day for ten workdays in May 2017, with a link to a brief online questionnaire about the preceding ftf interactions they had. They were asked to report all their ftf interactions 60 min prior to the prompts that were more than just a greeting (i.e., duration > 2 min) and took place inside the Flux building.

Measures

For the first part of the data collection, a questionnaire was designed that consisted of open- and closed questions about demographics (i.e., age or gender), user group (i.e., student or employee), department and role in the organisation (for employees). Respondents were also asked about their personality, based on the Big-Five dimensions, namely extraversion, agreeableness, conscientiousness, emotional stability and openness to experience (Gosling et al. 2003). To measure the five dimensions of personality, the Ten-Item Personality Inventory (TIPI) was used. The TIPI method includes 10 statements (i.e., 2 for every personality dimension) that were answered on a 7-point Likert scale ranging from (1) strongly disagree to (7) strongly agree (see Gosling et al. 2003).

Furthermore, respondents were asked whether they were a student (i.e. bachelor or master student) or employee. When people indicated to be a university employee, they were asked about their role in the organisation. The functions of the Dutch ranking system UFO (Universitair functie-ordening) were used, namely full professor emeritus, full professor, associate professor, assistant professor, university teacher/researcher, postdoc, PhD/PDEng, supportive and

management staff, secretary and interns. Thus, in the Dutch system, PhD/PDEng and research assistants are seen as employees and not as students. Respondents were also asked about their overall presence in the building and about the timeslot (i.e., start-and end times) of their normal work- or study day.

Table 2 shows the questions and answer categories of the ESM questionnaire of part two. First, respondents were asked about the duration of the interaction and about the type of interaction, namely whether the interaction was a social- or work-related interaction or both (e.g., Marouf 2007; Lawson et al. 2009). Next, they were asked about the main activity of the ftf interaction and could choose between a discussion, meeting, catch-up/chat, (business) lunch/diner, providing or receiving information/advice, network event, brainstorm session, lecture, training/presentation or other activity. These activity types were chosen based on previous literature about interactions (Tschan, Semmer, and Inversin 2004; Berends et al. 2006; Appel-Meulenbroek 2014). Furthermore, respondents were asked if the ftf interaction was pre-planned, intentionally unscheduled, or coincidental (e.g., Brown 2008; Koch and Steen 2012; Appel-Meulenbroek, De Vries, and Weggeman 2017). A lot of research has been done about knowledge sharing and its effect on the innovativeness and success of organisations (e.g., Ipe 2003; Easterby-Smith et al. 2008). Therefore, we asked respondents to indicate if knowledge was shared during the ftf interaction. Finally, respondents were asked to indicate the location of their ftf interactions in the academic building. Reporting about ftf interactions with more than three people were then marked as a group interaction and stopped here, because otherwise the questionnaire would be too time-consuming for respondents. With regard to non-group interactions, respondents were also asked to indicate the department where the contact person(s) of each interaction work(s) and their user group (i.e., student or employee).

Sampling

First, approximately 1300 students and employees were approached by an email, by the management of the departments, based on an available e-mail list of users. The management, unfortunately, did not have all the e-mail addresses of the 2150 users of the Flux building. The approached users were asked if they were willing to participate in both steps of the research. In addition, to increase the response rate, the Flux building was also personally visited by the

Table 2. Measures face-to-face interaction and tie characteristics.

Variable	Measurement level	Categories	
Type of interaction	Nominal	1.	Social interaction
		2.	Business related interaction
		3.	Both
Main activity (categories based on activities mentioned by Tschan, Semmer and Inversin 2004; Berends et al. 2006; Appel-Meulenbroek 2014)	Nominal	1.	Discussion
		2.	Meeting
		3.	Catch up/chat
		4.	(Business) lunch/dinner
		5.	Providing or receiving feedback
		6.	Network event
		7.	Brainstorm session
		8.	Lecture
		9.	Training/presentation
		10.	Other, namely:
Duration	Ratio	Duration in minutes (open question)	
Intentionality (adapted from Brown 2008; Koch & Steen 2012; Appel-Meulenbroek De Vries, and Weggeman, 2017)	Nominal	1.	Scheduled in advance
		2.	Intentional unscheduled
		3.	Initiated after coincidental visual contact
Location (adapted from Boutellier et al. 2008; Rashid, Wineman and Zimring 2009; Staplehurst and Ragsdell 2010; Hua et al. 2011)	Nominal	1.	Own workspace
		2.	Workspace
		3.	Meeting room
		4.	Lecture room
		5.	Project space
		6.	Lounge area
		7.	Informal meeting space
		8.	Coffee corner
		9.	Café/ restaurant area's
		10.	In the hallway
		11.	By the elevator
		12.	Space for copying/printing
		13.	Concentration room
		14.	Supermarket
		15.	Other
Group interaction (> 3 people)	Nominal	0	No
		1	Yes
Tie characteristic: department	Nominal	1.	Same department
		2.	Different department
Tie characteristic: user group	Nominal	1.	Student – student
		2.	Employee – student
		3.	Employee – employee

first author, to ask users in person if they were willing to participate in this research and to give their e-mail address or mobile phone number for the second part of the research. Overall, a total of 259 respondents completed the questionnaire of the first part of this research. Of these respondents, only 92 respondents also participated in the second part and reported a total of 643 different ftf interactions in the Flux building.

This sample of 92 respondents consists of 71% men and the average age is 32 years ($SD = 11.82$). More than half of the respondents in the sample are students (57%) and 60% is part of the Electrical Engineering department, versus 35% from the department of Applied Physics and 5% from other departments. Most employees in the sample are working as a PhD-student (28%), supportive/management staff (20%) or as an Assistant Professor (15%). As can be seen in Table 3, most interactions were a discussion (28%), a chat (20%), a formal meeting (19%), a lecture/ training (12%) or about receiving/giving feedback

(11%). More than half of the ftf interactions were reported as work-related interactions (61%). The average duration of the interactions was approximately 38 min ($SD = 48.57$), with a minimum of 2 min and a maximum of 360 min. Most ftf interactions were with people from the same department (86%). Regarding location choices, most interactions took place at the workspace (43%), meeting places (13%), informal meeting/project spaces (13%), eat- and drink areas (8%) and in lecture rooms (7%).

Analytic procedure

To analyse the bivariate relationships between personal characteristics, ftf interaction characteristics, contact person(s) characteristics and the location of the interactions, several Chi-square (χ^2) analyses and analyses of variance (ANOVA) were performed. Subsequently, a Mixed Multinomial Logit Model (MMNL) (see Hensher and Greene 2003) was used to analyse all hypothesised relationships simultaneously

Table 3. Descriptive statistics face-to-face interaction characteristics ($N = 643$).

	Mean	Sample (N)	Sample (%)
Interaction activity			
Discussion		171	26.6
Meeting		123	18.7
Catch up/chat		126	19.2
Providing or receiving feedback		73	11.1
Lecture, training/presentation		79	12.0
Other		71	10.8
Interaction type			
Social related		157	24.4
Work related		393	61.1
Both		93	14.5
Initiation of the interaction			
Scheduled in advance		269	41.8
Intentional unscheduled		232	36.1
Initiated after visual contact		142	22.1
Duration	37.6		
0–5 min		145	22.6
6–10 min		84	13.1
11–15 min		62	9.6
16–25 min		50	7.8
26–40 min		95	14.8
> 40 min		207	32.2
Location type			
Own workspace		177	27.5
Workspace other person		101	15.7
Formal meeting space		83	12.9
Lecture room/project space		48	7.5
Eat- and drink areas		51	7.9
Hallway		40	6.2
Informal project space/social space		81	12.6
Other, namely		62	9.6
Non-group interactions ($N = 400$)		Sample (N)	Sample (%)
Department			
Same department		339	84.8
At least one person from a different department		61	15.2
User group			
Same user group		301	75.3
At least one person from a different user group		99	24.7

in a single model (see Hensher and Greene 2003). The advantage of this state-of-the art discrete choice model over the more basic MNL model is that it is able to capture unobserved heterogeneity between individuals when multiple observations are obtained of each individual, as for every parameter a distribution is estimated (McFadden and Train 2000; Hensher and Greene 2003).

For the MMNL, the unit of analysis was a ftf interaction and the location choice was the dependent variable in the estimated model. The location alternatives for ftf interactions (see Table 1), based on the literature review, were categorised into the following five location types, to reduce the number of alternatives for the purpose of the analysis:

1. Workspace (base level) (i.e., own workspace, workspace other person)
2. Meeting room
3. Project-/lecture spaces (i.e., lecture room, project space, lounge area, informal meeting space)

4. Eat and drink areas/hallway (i.e., coffee corner, café/restaurant/canteen, in the hallway, by the elevator, space for printing/copying)
5. Other locations (i.e., concentration room, supermarket, other locations)

A random parameter was estimated for the utility constant term for each location alternative to capture possible heterogeneity in base preferences for locations. As the location alternatives might be correlated, the method of Cholesky decomposition was used (see Hensher and Greene 2003) to allow for these correlations.

Independent variables (i.e., ftf interaction characteristics, personal- and work-related characteristics and contact person(s) characteristics) were included as interactions with all the location type alternatives (e.g., gender * Location alternative 3). The coefficients of the interaction terms were estimated as non-random parameters, to reduce the degrees of freedom.

To estimate the final model, a stepwise process was used whereby interaction terms for one independent

Table 4. Results bivariate analyses.

	Interaction activity	Work/social relatedness	Initiation interaction	Duration	Knowledge sharing	Location type
User characteristics						
Age	**	**		**		**
Gender	**	*		**	**	*
Department	**	*	**			
User group	**	**		**		**
Role in the organisation	**	**	*	**	**	**
Extraversion						**
Agreeableness	*					**
Conscientiousness	**	*		*		**
Emotional stability	**		*			*
Openness to new experiences	**					
Face-to-face interaction characteristics						
Interaction activity						**
Work/social relatedness						**
Intentionality						**
Duration						**
Tie characteristics						
Composition based on department			**	*		**
Composition based on user group	*	**			**	

$^{*} = p < 0.05,$
$^{**} = p < 0.01.$

variable (which were found significant in the bivariate analyses) at a time where added to the model and nonsignificant independent variables were subsequently removed. This process was repeated until a model was estimated with only significant relationships. To estimate the final model, 1000 Halton draws (see Bhat 2003) were used.

Results

Results bivariate analyses

The role in the organisation influences all characteristics of the ftf interactions (see Table 4). For example, it was found that university teachers/professors are more likely to have longer interactions (Mean = 43 min.) compared to the researchers (Mean = 36 min.) and the supportive staff (Mean = 22 min.). Furthermore, it was found that men are more likely to have discussions and meetings, whereas women are more likely to have catch-ups or chats. Men also have longer interactions (Mean = 41 min.) than women (Mean = 27 min.). With regard to personality, more extraverted, emotionally stable and agreeable users more often use the workspace for ftf interactions compared to other personalities, whereas hallway area/eat and drink area are more often used by introverted and less emotionally stable users. In addition, a more conscientious (i.e., careful and hardworking) person is more likely to give or receive feedback than less conscientious people.

The analyses also showed that people's own workspace is mostly used to discuss, chat and to give/receive feedback, while informal meeting/project spaces are mostly used to chat and for presentations/lectures/events. On average interactions in meeting rooms took longer (Mean = 64 min.) than at the workspace (Mean = 22 min.) or in eat- and drink areas/hallways (Mean = 23 min.).

With regard to contact person(s) characteristics, a ftf interaction with participants from the same user group increases the probability that the ftf interaction is socially related. On the other hand, this decreases the probability that (new) knowledge is shared. Ftf interactions with at least one participant of another department were more often scheduled in advance, compared to ftf interactions with people from the same department. In addition, ftf interactions involving people from the same department were shorter (Mean = 25 min.) compared to ftf interactions with at least one participant from another department (Mean = 36 min.). Ftf interactions between people from the same department more often took place at the workspace compared to interactions between participants with at least one person from a different department, which are more likely to take place in a meeting room and/or in the hallway area/eat and drink area. No significant differences were found between ftf interactions with people from the same user group and ftf interactions with people from different user groups (i.e. students and employees).

Overall, Table 4 shows that most of the expected relationships between personal-, interaction, and contact person characteristics and the location type choice are confirmed by the results of the bivariate analyses. Only, people from different departments were not found to have different location choices for

Table 5. Results Mixed Multinomial Logit (MMNL) model.

Random parameters (location type)	Parameter (*t*-value)			
1. Workspace (base level)	0			
2. Meeting room	−0.909* (−1.68)			
3. Project -/lecture space	−0.075 (−0.17)			
4. Eat- and drink areas/hallway	−0.346 (−0.90)			
5. Other location	−0.742 (−0.39)			

Interaction variables (non-random parameters)	2. Meeting room	3. Project-/lecture space	4. Eat- and drink areas/hallway	5. Other location
Personal- and work related characteristics				
Age				−0.215** (−3.09)
Employee (dummy)	−1.107* (−2.41)	−2.441** (−4.61)		
Supportive staff (dummy)			−2.071** (−3.76)	
Face-to-face interaction characteristics				
Duration	0.024** (4.89)	0.025** (5.18)		
Intentional/unplanned (dummy)	−2.024** (−3.39)	−0.876** (−2.61)		
Catch up/chat (dummy)	−1.432* (−2.03)			
Discussion (dummy)	−2.067** (−3.44)	−1.364** (−3.22)	−0.739* (−1.93)	
Lecture, training/presentation (dummy)		1.151** (2.70)	1.159* (2.51)	
Meeting (dummy)	1.173** (2.81)	−0.976* (−1.91)		
Social interaction (dummy)			0.695* (1.72)	
Work related interaction (dummy)			−1.282** (−3.00)	

Log Likelihood function (LL(β))	−755.40			
Log Likelihood function null model (LL(0))	−1034.87			
ρ^2	0.400			
ρ^2 adjusted	0.391			

Note. Between brackets are *t*-values.
* = $p < 0.05$, ** = $p < 0.01$.

ftf interactions. Also, ftf interactions between students and employees were not found to take place at different location compared to ftf interactions between people from the same user group (i.e. contact person characteristic).

MMNL model results

Table 5 shows the estimation results of the final MMNL model, whereby Location 1 (i.e., workspace) was taken as the base alternative. As can be seen, the adjusted Rho-square of 0.39 indicated that the model performed well. The significant value of the standard deviations of locations showed that there exists heterogeneity among users of the Flux building, which means that there are differences between the participants regarding their choices for having interactions at specific locations. Figure 2 shows a visualisation of the significant results of the MMNL model.

First, as expected, the results showed that the probability that social interactions take place at eat- and drink areas/hallways was higher than for work-related interactions. So, H1 is accepted.

Next, relationships were found between the activities and the location choice. The findings suggested that the probability that catch ups/chats take place in meeting rooms is lower than for the other activities. A meeting room was probably a place where more planned and formal ftf interactions activities (e.g. formal meeting) take place. Discussions were also less

likely to take place in meeting rooms, and were common in project spaces/lecture spaces and eat- and drink areas//hallways compared to the other activities. As expected, the activity, formal planned meeting, was more likely to take place at meeting spaces and less likely to take place at project-/lecture spaces compared to other activities. Meeting spaces are specifically assigned for meetings, while project-/lecture spaces are not. The probability that lectures, trainings/presentations take place in project-/lecture spaces and in eat- and drink areas/hallways was higher compared to other locations. There might be an increase in interactive lectures that could also take place outside of a traditional project-/lecture space. These results confirm H2.

Furthermore, the results suggested that ftf interaction activities with a longer duration are more likely to take place at meeting spaces and project-lecture spaces compared to other locations. Thus, H3 is supported. Two negative parameters were found for intentional but unscheduled ftf interactions. This suggested that intentional but unscheduled interactions are less likely to take place at a meeting room or at a project-/lecture space compared to unplanned or planned interactions. So, H4 is accepted.

With regard to personal characteristics, the results showed that the probability that older people have ftf interactions at the 'other location' category (e.g., concentration room and supermarket) is lower than for younger people. So, H6 is supported. However, no
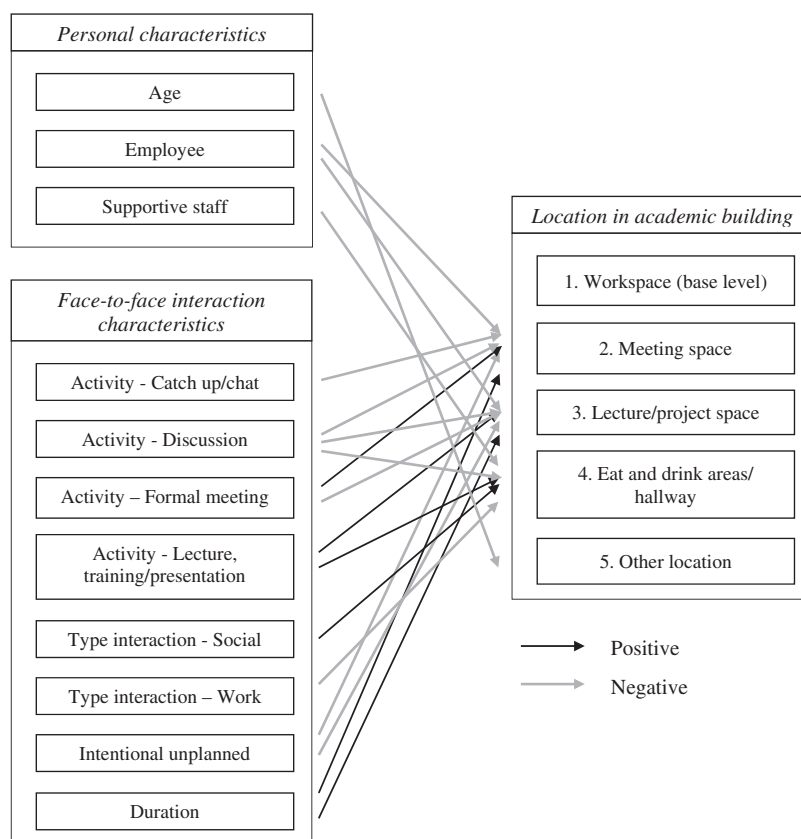
Figure 2. Visualisation significant relationships MMNL model.

Table 6. Correlation matrix for random parameters.

	2. Meeting room	3. Project-/lecture space	4. Eat- and drink areas/hallway	5. Other location
2. Meeting room	1.000	0.110	0.824	0.235
3. Project-/lecture space	0.110	1.000	0.194	0.507
4. Eat- and drink areas/hallway	0.824	0.194	1.000	0.507
5. Other location	0.235	0.507	0.507	1.000

significant relationships were found between gender, personality and the location type choice, thus, H5 and H7 are rejected.

No significant relationship was found between the respondents' department and their location choice. The results did show that user group (i.e. student or employee) is important for explaining the location choice, namely employees are less likely to have ftf interactions in meeting rooms and project spaces/lecture spaces than students. The negative parameter for supportive staff suggested that supportive staff were less likely to have interactions in eat- and drink areas/hallways compared to other user groups (e.g., academic staff). The supportive staff used other location types (e.g., their workspace) more often. Based on these results, H8 is partly accepted.

Finally, the results of the MMNL model in this current study did not show any significant relationships between contact persons(s) characteristics (i.e., same

user group and/or department) and the location type choice. So, H9 is rejected.

As can be seen in Table 6, high correlations between the utilities of the location alternatives came forward. Location 2 (meeting room) and Location 4 (eat- and drink areas/hallway) have a relatively high correlation value, namely 0.824. This means that people, who have frequent interactions in meeting rooms, are also likely to have frequent interactions in eat and drink areas/hallways.

Discussion

The aim of this study was to provide more insight into how user characteristics, interaction characteristics and contact person(s) characteristics are related to the location type choice of ftf interactions of students and employees in academic office buildings. Results of this study could help real estate managers of university

buildings to create work environments that stimulate ftf interactions among employees and students of different departments.

The results showed only a few significant relationships between user characteristics and the location type choice. First, the results suggested that older users are less likely to have ftf interactions at other locations (e.g., concentration room and supermarket) than younger users. It might be that older people are more used to take lunch from home, whereas most students often buy their lunch/snacks in the supermarket. Also, students (i.e., younger building users) more often use concentration rooms compared to employees, because most employees already have a (shared) closed workspace to concentrate. Although previous studies (e.g., Rothe et al. 2012) found age differences in the use of informal spaces (e.g., eat- and drink areas), this current study showed no relationship. Similarly, Rothe et al. (2012) and Yildirim, Akalin-Baskaya and Celebi (2007) found gender differences regarding their work environment preferences, but the results of the MMNL model showed no relationship between gender and the location type choice for ftf interactions in this academic building. Because of these conflicting results, more in-depth research is needed to explore age and gender differences in preferences for the academic office.

A significant relationship was found between the user group and the location type choice. Employees are less likely to have interactions at meeting spaces and lecture/project spaces compared to students. This was expected, as employees probably have more ftf interactions at their workspace, which is also often used as a meeting space. Although significant relationships were found with regard to the personality traits in the bivariate analyses, the MMNL model showed no significant relationships between personality and the location type choice anymore. This suggests that other indicators are more important for explaining the location type choice.

With regard to activities during ftf interactions, the results showed that lectures, trainings/presentations are more likely to take place in eat- and drink areas/hallways compared to other location types. This was not expected, as one can imagine that eat and drink areas/hallways are not suitable for lectures, trainings/presentations. It might be that the canteen or other lunch areas are used for specific types of presentations to students or staff. Further research is needed to explore this activity and its location(s) further. Perhaps there was a lack of space in those locations designed for these activities. As expected, catch-ups/chats are

less likely to take place in meeting rooms compared to other locations. Previous studies also found that casual conversations take place more often at individual workstations, informal areas (e.g., kitchen, coffee areas or café) or in the hallways (Davenport and Bruce 2002; Tschan, Semmer and Inversin 2004; Hua et al. 2011). More unexpected was the finding that discussions were found to take place less often at a meeting space and lecture/project space (and also at eat and drink areas/hallways, but that is not unexpected). This finding might be caused by the fact that in the ESM study only the main activity of the interaction was logged. Also, discussions might be most likely to take place at peoples' workspaces, which is also recognised by previous research in regular offices (Tschan, Semmer and Inversin 2004; Staplehurst and Ragsdell 2010). Although, users could disturb others or get disturbed when having ftf interactions at the workplace, they still prefer this location for discussions. Therefore, this result contradicts the findings by Babapour and Rolfö (2019), who found that, based on observations and interviews, people who work in more open zones have the tendency to speak more quietly to limit the distraction for colleagues. On the other hand, this result was also confirmed by Heinzen et al. (2018) found that workers, who moved from an enclosed office to a more flexible and open office, showed a decreased number of interactions at the labs and an increase of interactions at people's workspace as lab work requires focus and concentration. Thus, probably workplaces are important locations for inspirational activities and meeting spaces and lecture/project spaces are important for activities related to coordination and information. However, further research into activities would be valuable to find out whether certain locations are functioning as intended when they were designed.

Regarding the characteristics of the ftf interaction itself, as expected, social interactions are more likely to take place at eat and drink areas/hallway (i.e., informal meeting spaces) compared to work-related interactions, confirming previous studies (Davenport and Bruce 2002). As this type of interaction is most likely to be unplanned and an inspirational activity (i.e. spontaneous and could occur between people from different departments or projects), it is important to stimulate these interactions in academic offices (e.g. Allen and Henn 2007). Intentional but unscheduled interactions were found to take place less often at a meeting room or at a project-/lecture space compared to other locations. In addition, the probability is higher that the duration of ftf interactions is higher when they take place

in a meeting room or at a project-/lecture space. These results suggest that more scheduled and longer interactions take place here, probably because these spaces need to be reserved in advance. That they are not used for unscheduled interactions could point out that either they are always full (e.g., capacity might be too low) or that people do not move to another location after such unplanned interactions have started.

The results of the MMNL model showed no significant relationships between contact person(s) characteristics and the location choice of ftf interactions. On the contrary, previous studies did show that people from different groups have different ftf interaction patterns (e.g., Wineman, Kabo, and Davis 2009; Kabo et al. 2015). The findings might suggest that personal characteristics and ftf interaction characteristics might be more important indicators for choosing a specific location type than contact person(s) characteristics. Or it could be that in academic buildings this relationship is different. On the other hand, the bivariate analyses showed that contact person(s) characteristics (i.e., user group and department) did significantly influence ftf interaction characteristics. Further research is needed to analyse if these interaction characteristics are a mediator between contact person(s) characteristics and the location type choice.

Overall, this study showed less significant relationships between user characteristics and the location type choice than in studies in regular office buildings. On the other hand, with regard to ftf interaction characteristics, no differences were found in location choices between academic offices and other office types. This suggests that similar office concepts could be offered in both office environments to stimulate social and/or work-related ftf interactions among employees.

Conclusion

Offices have changed due to the NewWoW principles, which make it possible to work place and time independently (Bijl 2007). However, the physical office will always be essential for having ftf interactions with others (O'Kane, Palmer, and Hargie 2007; Greene and Myerson 2011; Allen and Henn 2007). These ftf interactions are recognised to be important for people's productivity, job satisfaction and organisational commitment. Therefore, there is a growing interest in people's social behaviour in (new) office concepts (e.g., De Croon et al., 2005; Rolfö, Eklund, and Jahncke 2018). As research about ftf interactions between different users in academic buildings (i.e., students and employees) is limited, this study contributes to existing theory

by analysing factors that influence the location type choice of ftf interactions of students and employees in such buildings. In addition, this study used real-time data, derived through ESM, to analyse ftf interaction patterns, using a state-of-the art discrete choice model approach (i.e., MMNL model), which is not common in the field of workplace research. This led to more realistic data and insights on user behaviour in the academic workplace.

Results of this study are relevant for academic organisations and the design community, as it provides more insight in which locations in academic buildings are important for ftf interactions of different user groups. For example, it is important that sufficient meeting rooms and concentration rooms for students are designed, as this user group uses these spaces more often compared to employees, who have more interactions at their workplace. It is also important that the more informal areas (e.g. canteen/café) are also made attractive for employees, so that spontaneous encounters between students and employees and different departments are promoted. This information could help office designers to optimise academic offices and design an interactive work environment that stimulates the ftf interactions most desired by their clients.

The results are also interesting for HR-managers. With these results, they get more insight in which type of users use certain location types. HR managers and property managers should work together to monitor the preferences and needs of workers with regard to ftf interactions in the office, so that they can adapt the physical work environment more easily to these preferences and thus offer better support and a more attractive work environment. This could increase the productivity, job satisfaction and user experience of workers, which eventually could help to attract and retain talented knowledgeable workers (e.g., Earle 2003; Haynes 2011).

This study revealed several relationships, but statements about the direction of the causality for the relationships cannot be derived, which is a general limitation of cross-sectional studies. Another limitation of this study is that it is based on only one academic building on a campus in Eindhoven in the Netherlands. Furthermore, the original workplace concept of the Flux building was based on the ABO concept. However, in practice, the building is still used in a traditional way (i.e., fixed workplaces) by part of its users (i.e., some of the academic staff). Therefore, it is not possible to generalise the outcomes to other traditional academic buildings or academic buildings

where the ABO concept is applied in and outside the Netherlands. In addition, further research is needed in different types of academic buildings that house different departments. Including other forms of interactions in future studies (e.g., e-mail, phone calls, Social media or FaceTime) could give more insight into communication patterns of students and employees in academic buildings. Also, analysing the influence of ergonomic aspects (e.g., furniture, noise, temperature) of the work environment on location preferences for ftf interactions in more detail is interesting for future research. And last, further research is needed to analyse how an academic work environment could be designed that not only optimises the support of interactions, but also optimally facilitates privacy and concentration and the right balance between both ends of the spectrum.

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