

Human Movement in Healthcare Facilities: A Measurable Factor?

A lot of research you do during your first years of architecture studies feels useless; at the beginning of each project the professor expects you to do the same trick. You take your fancy marker-set out of your drawer, teachers love old fashioned hand drawing, and you start analyzing everything in the area of your given project location with the use of Google Maps. You draw bike lanes, locate supermarkets and circle big stations. But you never learned how to use these analyses; it feels like an empty point on the checklist. After this so called 'research part' you start designing and within this process you find questions and by answering these questions there are even more questions and this leads you to the actual research without being aware of it. This awareness of doing research, and using different research methodologies, is not always obvious. Later in my studies I learned how to do my research more conscious, I was aware that I was doing research and I learned that I had to document it in some way. But systematically documenting what you read, what you are searching for and most importantly what you learned from it in an accessible way is still hard. Because how do you document it in a way that later in your design process you can use the data to make found design decision? I was very pleased with the examples of the praxeology lecture about the study of human action and conduct. I think it is interesting to see how you can map the movement of people, shown in an example of Bruno Taut¹ and Christine Frederick². How simple a research can be documented and explained. This way of thinking, tracking and mapping human movement, influenced the way I look at my graduation project: seeing the user as a measurable factor that you can document instead of an imagined variable. Drawing a line because there is actual human movement and not because there is a bike lane on Google Maps.

During my design process I am always focused on the functional use of a design, finding logic in everything. I see architecture as completing a fun, interesting, complicated puzzle. As a problem with a solution, I just have to find it. This practical approach fits within my graduation studio, the Health Lab. The lab is focused on the practical and functional aspect of healthcare design as well as the user involvement to create a realistic project. For my graduation I am working on a current healthcare project in Ivory Coast with AMPC International Health Consultants and a local design team. The project involves the realization of approximately 10 small scale Maternity Clinics initiated by the National Health Development Plan to reduce maternal and infant mortality in the Ivory Coast. The challenge of this project is to design Maternity Clinics within the customs and possibilities of the Ivory Coast based on our (western Europe) healthcare knowledge. To reach this goal I will, among other things, research Dutch and French Maternity Clinics and wards to create a typology. A systematic approach to describe the variation and common ground to construct a manual on how 'our' system works, looking at facilities, physical spaces, routing and use. Within this typology research I want to intergrade a praxeology research, trying to track and map human movement within the ward.

Movement and routing is a key element within a healthcare facility and should function as the backbone of the design through different scales and users. That is why the research in my design process always starts with mapping out the functions and draw the different connections and traffic flows. For example: on the large scale there are service corridors, a clean corridor and a dirty corridor, these corridors facilitate traffic flow of clean and dirty items separately and therefore should never adjacent³; and on the smaller scale there is the routing within a department or ward. On the other hand you have to deal with patients and visitors who interact with the medical flows on different levels and scales, not to mention the importance of way finding within the whole healthcare facility⁴. To go back

¹ Bruno Taut, *Die Neue Wohnung: Die Frau als Schöpferin*, (Leipzig: Klinkhardt & Biermann, 1926), abb 49

² Janice Williams Rutherford, *Selling Mrs. Consumer: Christine Frederick and the Rise of Household Efficiency*, (Georgia: University of Georgia Press, 2003)

³ SKM Rao, 'Designing Hospital for better infection control: an Experience', *Med J Armed Forces India* 60, (2004), 63-66

⁴ Aysu Baskaya, et al., 'Way finding in an Unfamiliar Environment: Different Spatial Settings of Two Polyclinics', *Environment and Behaviour* 36, (2004), 839

to the point, to design a functional healthcare facility you have to take a lot of (interacting) traffic flows in consideration and you need to try to keep all lines as short as possible. Because I am designing a small scale Maternity Clinic for my graduation project I want to look closer to the previously mentioned small-scale flows within a department by not only analyzing the connections and physical space but also by tracking the human movement within the space.

New build 'state of the art' hospitals, like the Erasmus MC in Rotterdam, advertise the use of Evidence Based Design (EBD) to improve human-environment relations, this means that they use design solutions that have proven themselves in earlier designs. Erasmus MC explains that in order to realize a healing environment for patients and visitors and an optimal work environment for (medical) staff it is important to find a balance between the infrastructure and (architectural) design. Therefore two factors played a significant role in the design of the hospital. The first factor is the efficiency and sustainability of the building. The second factor is developing and integrating a new way of working within the Erasmus MC⁵. Accordingly Erasmus MC created 72 new workflows that are intergraded and adapted in the architectural design.⁶ But EBD is, just like Post Occupancy Evaluation (POE), a research method that is based on the evaluation of human-environment relations within a building that is already build and in use^{7,8}. Hadas Sopher et al. states that we need to look forward instead of looking back: '*Though this knowledge (EBD and POE ed.) may be useful for designing the next building, it is of little use during the design process of the examined building itself, when design errors could still be identified en fixed*'⁹. Sopher et al. explains that nowadays architects can use computational tools to examine almost everything, from calculating the structure to test run the light settings. But the evaluation on how the building will be used by its future users is still based on the architects knowledge and intuition. There are computational human behavior evaluation techniques that relay on Agent Based Modeling (ABM) that evaluate ergonomic issues for individual users such as wheelchair accessibility. But Sopher et al. states that most human activities are social and involve individual users that work together, a factor that ABM cannot handle. Additionally they claim that adding human behavior simulation to design representation tools is a missing component and inseparable of the spatial settings that generate a place. That is why Sopher et al. created the Actor Profiling Model (APM) a computational system that simulates human behavior relying on Event-Base Modeling (EBM). EBM simulates events based on described behavior patterns involving three interacting elements: space, activities and actors. The space communicates certain parameters that allow activities to take place and is influenced by the presence of actors. The activities are described as narrative that contains a list of actions that actors have to complete to achieve a goal within a particular space. The actors are dynamic entities that can perform activities and are influenced by the space. That is to say that all elements communicate with each other. The addition of APM is that it defines different actors with a personal profile in order to determine if and how activities will be executed. The profile contains the characteristics and abilities of the actor complemented with personal preferences towards their environment, the current state of the changing physical conditions of the actor and their knowledge. This knowledge can grow by repeating patterns or by interacting with other actors, in other words actors can learn from their environment and a social setting is simulated. The APM is demonstrated in a case study involving visitors in a hospital environment. Although the program is still a work in progress it is a step towards computational pre-occupancy human behavior evaluation and it provides the possibility to identify and fix social errors in a design¹⁰.

⁵ Liesbeth van Heel, *Ons Nieuwe Erasmus MC: Klaar voor de toekomst*, (Gouda: Het Staat Gedrukt, 2018), 2

⁶ Liesbeth van Heel, *Ons Nieuwe Erasmus MC: Klaar voor de toekomst*, (Gouda: Het Staat Gedrukt, 2018), 35

⁷ R.S. Ulrich et al. 'A Review of the Research Literature on Evidence Based Healthcare Design', *HERD: Health Environments Research & Design Journal* 1(3), (2008), 61-125

⁸ National Research Council, *Learning from Our Buildings: A State-of-the-Practice Summary of Post-Occupancy Evaluation*, (Washington DC: The National Academies Press, 2001)

⁹ Hadas Sopher, et al., 'Simulating Human Behaviour in (Un)Built Environments: Using an Actor Profiling Method', *International Journal of Computer, Electrical, Automation, Control and Information Engineering* 10(12), (2016), 230

¹⁰ Hadas Sopher, et al., 'Simulating Human Behaviour in (Un)Built Environments: Using an Actor Profiling Method', *International Journal of Computer, Electrical, Automation, Control and Information Engineering* 10(12), (2016), 230-239

There are more developments in the field of build and design concerning praxeology. For instance POE is getting more precise with 3D tracking¹¹ and it is even possible to do real-life ABM by using real persons in a VR setting¹². Other fields of expertise are also transitioning from looking back towards looking forward when it comes to human movement and behavior. For example the field of traffic control, nowadays Google Maps with Google Live Traffic is a common device to calculate an accurate travel time that takes the current traffic into account. But before the tech giant invented their traffic system the Traffic Message Channel (TMC) updated the driver with traffic reports. TMC received information from among other traffic cameras, inductive loops and the police and then broadcasted this information on the FM frequency band. But the information was always a bit outdated for the simple reason that the process of detecting, transmitting, broadcasting and receiving was quite slow. The market changed when the growing popularity of smartphones provided the possibility to constantly track people. Google jumped the opportunity and developed Google Live Traffic by tracking the GPS and Wi-Fi signals, also called Floating Car Data (FCD), of its users. Google transmits the FCD to current traffic flows and most importantly detects traffic jams and offers alternative travel routes¹³. The tracking of human movement with FCD is (almost) real-time; and contributes to the ability of looking forward and predicting human movement. As a matter of fact Google already uses the movement patterns of FCD to predict the prospective traffic, depending on the day, time and weather. However these predictions are only possible if there exists analytic data from that particular road. To predict traffic flows for non-existing roads, during the design of a new infrastructure, the earlier mentioned ABM comes in use. Because there are (nearly) no social interactions and all cars will drive the same way it is possible to simulate human movement and consequently detect and fix design flaws for a better and safer traffic flow¹⁴.

As I stated before I like finding the logic in things, for me creating a design always starts with the functional use. This means that a building should have an optimal infrastructure but it should also offer comfort to its users. To computationally simulate the user and finding an optimal flow does not automatically lead to comfort for the user. Perhaps in area of way finding, people feel comfortable if they know where to go or how to get somewhere. But generating an optimal (work) flow does not tell you how to design a space in terms of atmosphere, scale and material. These are the facets of design that turn a diagram into an architectural building. Because a medical facility should be more than an optimized medical factory; it should be a healing environment where patients feel safe, visitors feel welcome and where the (medical) staff can work with pleasure. That is why I think that programs like APM and ABM are perfect to test-drive a floor plan or a (work) flow but I also think that as an architect you still have the obligation to talk to the users; use your knowledge and intuition to design a functional and comfortable building. For example, during a guided tour in the Erasmus MC the guide explained that the hospital designed new optimized workflows with EBD but the nurses keep complaining about the setup. That made me question that if the nurses cannot work with the new setup how can you claim that it is optimized? And should the workflow adapt to the preferences of the nurses or should the nurses adapt to the new EBD workflow? To make it more general, what is more sufficient: user involvement during the design process or computational simulating users with APM in order to create an optimal workflow? I think that the pending question with all the technology that supports an architect with his/her design decisions is if all this knowledge and so-called 'fact-based design' will automatically conduct to better architecture? What leads us to the question: what is good architecture? And how do you examine good architecture if there are no fact-based parameters? For me good architecture is a completed puzzle, one that has an optimal routing, one that offers comfort to its users and not to forget one that is beautiful.

"When I'm working on a problem, I never think about beauty. I think only how to solve the problem. But when I have finished, if the solution is not beautiful, I know it is wrong." Buckminster Fuller¹⁵

¹¹ Urs Hirschberg et al., '3D Motion Tracking in Architecture: Turning Movement into Form - Emerging Uses of a New Technology', eCAADe 24(3), (2014), 114-121

¹² Chieh-Hsin Tang et al., 'Using Virtual Reality to Determine how Emergency Signs Facilitate Way-Finding', *Applied Ergonomics* 40(4), (2009), 722-730

¹³ Tobias Jeske, *Floating Car Data from Smartphones: What Google And Waze Know About You and How Hackers Can Control Traffic*, (Hamburg: Black Hat Europe, 2013), 4-5

¹⁴ Patrick A.M. Ehlert et al., 'Microscopic Traffic Simulation With Reactive Driving Agents', *Conference: 4th International IEEE Conference on Intelligent Transportation Systems At: Oakland, CA*, (2001), 861-866

¹⁵ David J. Darling, *The Universal Book of Mathematics: From Abracadabra to Zeno's Paradoxes*, (Hoboken: John Wiley and Sons, 2004), 34