Institution: Bournemouth University
Unit of Assessment: UOA 4
Title of case study: Facilitating efficient wayfinding in complex human environments.
1. Summary of the impact (indicative maximum 100 words)

Losing one's way in complex built environments wastes time and money, and often causes stress and anxiety. The BU Wayfinding Research Centre (WRC) has developed a research-driven, evidence-based approach to this common problem. Researchers have translated wayfinding knowledge from laboratory research on navigation and icon interpretation to a diverse range of private and public sector organisations (Frankfurt International airport, World Heritage Site, multi-national offices, hospitals). The method has replaced existing, unreliable navigational supports, typically based on intuition and guesswork, with effective, scalable, research-based solutions. These have improved wayfinding in complex, unfamiliar buildings, enhancing organisational productivity and reducing users' inconvenience, distress and risk. The successful delivery of the WRC's approach proves this method works and has significant potential for future application and development.

2. Underpinning research (indicative maximum 500 words)

Wayfinding—the ability to find, retain, and communicate routes through complex environments—is vital to everyday activity. Human spatial navigation performance is, nevertheless, remarkably variable; sometimes seemingly effortless, but often highly error-prone. Errors, which have trivial or critical consequences (e.g., retracing steps; missing a flight; risk of death), arise because wayfinding is in fact an exceedingly intricate cognitive task, involving both fundamental mechanisms of learning and memory and higher-order symbolic and verbal learning processes.

BU's focus on wayfinding was established when McDougall was appointed (BU 2007 to present). Her on-going research programme in symbolic processing of icons/signage was complemented by Wiener (BU 2009 to present), who provided a neuroscience and computational perspective on spatial navigation.

These appointments led to the launch of the Wayfinding Research Centre (WRC), which quickly made collaborative research links with UK and European institutions, including Edinburgh, Warwick and Freiburg University in Germany among others.

WRC's mission is to develop a deeper understanding of how basic and semiotic cognitive processes interact to guide behaviour, particularly in complex man-made environments. BU has committed substantial infrastructural funds to wayfinding research, investing £210K in laboratories, eye-tracking equipment and postgraduate studentships.

Key outputs include:

- Wiener's work on the relationship between gaze and subsequent wayfinding decisions, pinpointed two distinct cognitive mechanisms underlying estimates of current spatial position relative to a journey's origin (P4&5). Moreover, his collaborative studies with colleagues in Freiburg showed that these implicit direction-finding mechanisms operate differently from those that underpin the social or verbal communication of a route to others (P1).
- McDougall's complementary, theoretically-driven research has investigated icon identification, usability and appeal. For example, drawing parallels with picture naming (P3), showed how signs can be designed to make them more easily interpreted.

Wiener and McDougall's work came together through funding from Cisco Systems to develop signage systems for intelligent buildings (G2). The grant supported the development of a scalable

wayfinding intervention protocol that has subsequently been deployed in a range of applications (section 4).

WRC's research programme continues to develop. McDougall has recently been commissioned by the UK British Standards Institute (BSI) for similar work in relation to BSI and Wiener is now exploring how individual factors such as cognitive ageing (P6) and Post-Traumatic Stress Disorder (PTSD) affect wayfinding. A better understanding of the processes involved will lead to bespoke solutions to wayfinding difficulties experienced by older adults and professions that both risk trauma and require navigational competence (e.g. armed forces, emergency services).

To summarise, internal infrastructural support and industrial research funding has allowed WRC to conduct well-controlled, laboratory-based research, strongly informed by theory, to conceptualise the processes underlying human navigation through complex environments from first principles. Wayfinding systems fail when they ignore these principles. They have been applied to develop a research-driven, evidence-based solution to wayfinding, which is scalable across a range of important applications. This theory-driven solution is in marked contrast to a blind reliance on guesswork, intuition or a piece-meal use of empirical methods seeking merely to find out "What works here?"

3. References to the research (indicative maximum of six references)

Publications

P1. Hölscher, C., Tenbrink, T. and Wiener, J.M. (2011). Would you follow your own route description? Cognitive strategies in urban planning. *Cognition*, 121, 228–247. DOI: 10.1016/j.cognition.2011.06.005.

P2. McDougall, S., Forsythe, A., Isherwood, S., Petocz, A., Reppa, I. and Stevens, C. (2009). The use of multimodal representation in icon interpretation. In: D. Harris (ed.), *Engineering, Psychology & Cognitive Ergonomics*, HCII 2009, LNAI 5639, pp.62-70.

P3. McDougall, S. and Isherwood, I. (2009). What's in a name? The role of graphics, functions, and their inter-relationships in icon identification. *Behavior Research Method*s, 41, 325–336. DOI: 10.3758/BRM.41.2.325.

P4. Wiener J.M., Hölscher, C., Büchner, S. and Konieczny, L. (2012). Gaze behaviour during space perception and spatial decision making. *Psychological Research*, 76(6), 713–729. DOI: 10.1007/s00426-011-0397-5.

P5. Wiener, J.M., Berthoz, A. and Wolbers, T. (2011). Dissociable cognitive mechanisms underlying human path integration. *Experimental Brain Research*, 208, 61–71. DOI: 10.1007/s00221-010-2460-7.

P6. Wiener, J.M., de Condappa, O., Harris, M.A. and Wolbers, T. (2013). Maladaptive bias for extrahippocampal navigation strategies in aging humans. *The Journal of Neuroscience*, 33, 6012–6017. DOI: 10.1523/JNEUROSCI.0717-12.2013.

Key grants/research income

G1. BU support to establish WRG: £210K. From 2010–date.

G2. 2010–2013: McDougall, S. and Wiener, J.M. The development of signage systems in intelligent buildings. Cisco Systems Inc. (UK). £25k.

4. Details of the impact (indicative maximum 750 words)

WRC's work has achieved impact through valuable research-based consultancy to a range of organisations. Through this work WRC researchers have trialled a number of theoretically derived interventions, providing a research-driven, evidence-based solution to improve signage and mapping. This improves wayfinding amongst users of the facilities.

The following are a few examples of those organisations using WRC services. These illustrate the reach of the work across a variety of domains and its significance in terms of beneficiary groups. Each presents different practical wayfinding challenges to a diverse variety of users. The successful application of the approach is evidenced through field testing, endorsements from

senior managers within the organisations, further demand for WRC services and BSI research commissioning.

Frankfurt Airport, Germany (FRAPORT)

FRAPORT is the second busiest hub in Europe and one of the 10 busiest airports in the world (56 million passenger movements in 2011). This massive facility requires communication of both fixed (e.g., duty-free concession) and frequently changing (e.g., gate) location information. FRAPORT caters to transient users from all over the world, speaking different languages and using different writing systems. However, wayfinding typically follows fixed cognitive scripts, familiar to many travellers (e.g. departure; arrival; transfer.)

Having identified problems with the existing signage system at critical transfer locations, Wiener, in collaboration with his colleagues at the Centre for Cognitive Science, Freiburg University, conducted empirical eye-tracking studies to evaluate alternative wayfinding signage designs (R1). Research-led improvements to the signage system were made in 2011. Although operational constraints prevented a formal evaluation, airport staff reported substantially reduced passenger direction enquiries and FRAPORT management positively endorsed the changes.

In a letter addressed to Wiener, dated 06/06/2012, Head of the Wayfinding and Signage Department at FRAPORT stated: “Based on the results from these studies, the signage system at these critical transfer situations has been modified and improved. Reports from FRAPORT employees indicate that these modifications led to a substantial reduction of the number of passengers asking for directions” (R2).

This programme of work is on-going and WRC is currently investigating general design principles for complex wayfinding signs that will inform further modifications of the existing signage system.

Old Royal Naval College, Greenwich (Greenwich)

Greenwich is a World Heritage Site with several entrance and exit points. It seeks to provide a better educational/leisure experience for its multi-national visitor profile by improving pedestrian flow and increasing visitor donations.

In 2013 the WRC team was contracted to gather navigational survey and ambulatory eye-tracking data relating to placement of signs encouraging visitors to donate (R4). Analysis of the eye-tracking data provided the management team at Greenwich with key information about where to place donation signs and insights into visitors’ experience of the attraction and the ease with which they were able to find their way around.

The site’s Commercial Director said: “The eye-tracking survey carried out at the Old Royal Naval College was a revelation as it exposed what visitors are really looking at.” She continued, “It highlighted some significant gaps in our wayfinding system, as well as issues around the visibility of our donation boxes, all of which are now being addressed to improve both visitor experience and fundraising opportunities” (R5).

Development of International Sign Standards

International Standards have been developed to assess comprehensibility of signs and symbols which reference work by McDougall as a basis for the methods used. These guidelines have also been adopted as British Standards (R6). McDougall is currently helping with pilot work to develop updated comprehensibility standards (i.e. ISO 9186-3). Recommendations regarding US homeland security safety symbols has also cited work by McDougall (R7) and recommendations for revisions to design guidelines for pictorial communication symbols in Japan is in part based on work by McDougall (R8).

In summary, the WRC's research-driven, evidence-based approach to wayfinding problems has provided a solution where previously only unreliable navigational supports, typically based on intuition and guesswork, existed. The successful delivery of the WRC's approach proves this method is an effective, scalable, research-based solution with significant potential for future application and development. Those using these facilities will continue to benefit from significantly improved wayfinding ability.

5. Sources to corroborate the impact (indicative maximum of 10 references)

R1. 2009–2013: Wiener, J.M. Signage at Frankfurt Airport: The efficiency of the existing system. FRAPORT AG. £6.5k.
R2. Personal letter from Head of Wayfinding and Signage Department, Fraport (available on request).
R3. Methodological Triangulation to Assess Sign Placement http://www.jan-wiener.net/publications/Buechner_etal_ETRA2012.pdf
R4. 2013: Wiener, J. and Miller, J. *Old Royal Naval College Greenwich: Establishing a better sense of place.* Old Royal Naval College Greenwich. £15k.
R5. Personal letter from Commercial Director of Old Royal Naval College, Greenwich (available on request).
R6. ISO 9186-2: 2008. *Graphical symbols – Test methods. Part 2: Method for testing perceptual quality*. International Standards Organisation.
R7. Mayhorn, C.B., Wogalter, M.S. and Bell, J.L. (2004). Homeland security safety symbols: Are we ready? *Ergonomics in Design*, 6–14.
R8. Morimoto, K. and Matsumoto, K. (2007). Design guidelines of pictorial symbols for communication support based on subjective evaluation of comprehensibility. IASDR07, 1–3.