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# "SEARCH DON'T SORT": IMPACT AND IMPLICATION ON USER PERFORMANCES THROUGH INNOVATING HOSPITAL SYSTEMS WITH DIGITAL WAYFINDING

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## ABSTRACT

*Wayfinding is and has remained critical to help users find their way based on four key points; current location, end destination, best route and route maintenance. Supporting users within the digital era, digital wayfinding initiatives have risen exponentially in practice and research yet, there remains the challenge of seeking a seamless version of physical into digital user legibility. Specifically addressing the healthcare sector, this paper materialises through the lens of Lynch's Theory of a good city form and mapping metrics of user experiences in hospital navigation benchmarked against the longevity measures for hospital economic efficiency. Innovating hospital systems with digital wayfinding is analysed using automated, randomised and accurate opportunities to optimise a tailored-led approach, otherwise considered 'searching' according to user preferences. For digital wayfinding research, this paper provides a new layer of analysis and a potential model for wayfinding management in terms of automating to meet future evolving needs.*

Keywords: Wayfinding, digital wayfinding, innovation, hospital systems, design-led

## INTRODUCTION

The digital wayfinding (DW) agenda reflects a modern application to designing a wayfinding system in the shape that, Kevin Lynch (1960) *The Image of the City* had coined wayfinding to be. Central to accompanying the increasing demands of personalising user needs to orientate and navigate routes the pertinence to understanding human experience with space remains (Patel *et al*., 2006). However, there appears a gap between the way users navigate outside, altered by DW, to indoors where spatial planning continues top-down (Pissourios, 2014). Specifically addressing hospitals, the formation of space is challenged by meeting users expectations and in turn, user performance is affected and economically detriment.

Although the latter of DW characteristics is contended and has come as a challenge for users to split users visual senses between static and digital to navigate (Massiceli et al., 2018). This disputes user ability for cognitive mapping and recognition of the physical environment. Comparatively, DW also emerged as an offering to meet differentiated styles of learning spatial perceptions and knowledge required to meet user legibility (Wang and Shen, 2012). The controversial role of DW triggers a cultivating curiosity in understanding how to innovate a symbiosis of physical and digital navigable systems from a user's needs of wayfinding. By examining an elucidation of factors that have a current impact to user performance, would make as critical findings for hospitals as researchers fuel this symbiosis between physical and digital information as, inevitable (Jeffrey, 2017).

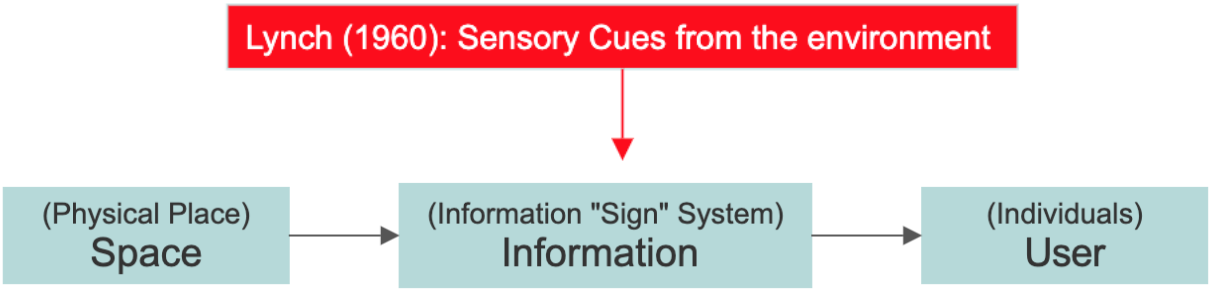
Contemporary challenges faced by hospital systems with spatial orientation has had many ramifications from other fields and appears that the operational principles remain the same. It became apparent that an aspired symbiosis, Mollerup (2009) confirms it is not to add to the scarcity of information which can also cause disorientation in hospitals. As information overload is another taxonomy problem, limited research has explored whether there is a structural problem in the system as a way to embrace DW. Understanding ways to optimise a symbiosis within planning is revised through Lynch's Theory of a good city form (1960). While most research professionals, propose several innovative DW solutions (Apelt *et al.*, 2007), it is when benchmarked between user performance with economic efficiency; merely innovating hospital systems with DW appears not enough.

In this paper, it opens with a brief overview of DW's development and its critical arguments for and against its growth across the 15 years. Tracing the legacy of Lynch into a digital era, planning requires engaging with the principles of DW and the impact it has on innovating hospital systems. A bottom-up planning method of 'searching' user preferences is proposed, implicating a diversified design DW can offer to user performance and counteract predicting travel behaviour. Finally, this paper concludes with some final remarks and area for future research.

## PRINCIPLES OF WAYFINDING

Kevin Lynch (1960) seminal work on how users navigate from place to place coined the term wayfinding referring to the techniques used to find unknown or mislabeled routes and ongoing maintenance. Formerly defined as "a consistent use and organisation of definite sensory cues from the environment" (Lynch, 1960). The revolution for signage is followed in the 1970s, founded Society for Environmental Graphic Design, where designers shifted from artistic architectural vision towards integrating function in physical space for user orientation (SEGD, 2014). Since, wayfinding referred as information systems its definition advanced to "strategically connect individuals to a physical place, constituted by a sign system and designed as a network" (Shamsuddin *et al.*, 2018), *figure 1*. Both, Weisman (1981) and later, Garvey (2007) verify, wayfinding is a principle for legible recognition. Although hospital movement inefficiency largely defied in the literature (Campbell and Scott, 2014). A setting under user points of "stress, anxiety and uncertainty" instantaneously requires connecting diverse needs (Short et al., 2017) and their progressive development to reflect changing patterns of use.

***Figure 1:*** Principle of Wayfinding from Lynch (1960) and Shamsuddin *et al*., (2018).




In the last 15 years, digital wayfinding (DW) has grown exponentially, heightening a user socio-technological push (Churchill and Ubois, 2008). DW defined as a channel that maximises the freedom a user has, capturing information from analytics, to automate personalised route navigation and maintenance (Symons, 2016). This impacted driven connectivity and solidating the gap between "the environment and to the observer", ultimately, adding higher value to the asset and lessened change from disorientation (Gibson, 1986; Nagar, 2006). Although, Sielker (2019) states that data has been used significantly less for planning and design than other fields. With 25% of software having become location-aware (Smith, 2017) areas that have primarily benefited include; retailers using app technology to text users when they are near to businesses known as, geofencing. Also, social networking purging calls and mapping their location using digital information to communicate known as, geolocation (William *et al.*, 2017). It appears since users want to integrate their experiences, the location-based services from DW solutions opportunities with; navigation information, personalised locators and instant communication (Michael, 2011).

Rather than using the contemporary universal system, DW can tailor the experience (Calori *et al.*, 2015). It appears digitally adapting is pre-conditioned a smart choice to support buildings digitalise (Cabinet Office, 2011) and thus, information can personalise experiences through user data input made available, such as habits and movements (Perkins, 2008). DW also demonstrates largely impacted by outdoor route navigation including, Google Map and City Mapper that offers directions of cartographic information leveraged from increasing data, consequently disrupting economies (ibid). Although an interactive relevance within indoor public areas, has yet been unveiled (Goodchild, 2007). One reason, SEGD (2014) identifies digital solutions broadly have been commercial, promotional and advertising led, since, the initial investment remains high. Decisively, their fee dependent system hinders digitalising 'information commons' to take root elsewhere (Sielker, 2019). Thus, converting a hospital's universal systems and optimise user experiences, its dependability requires also weighing its economic investment value.

## DIGITAL WAYFINDING GROWTH

The diversification in user experience demonstrates a significant shift in wayfinding expectations relative to narrow user biases. The prevalence for DW accuracy and speed encapsulated, are two fundamental mechanisms, Global Positioning System (GPS) with a Geographic Information System (GIS) compressed through algorithms, (Cornell *et al.*, 2008; Axon *et al.*, 2012). Firstly, GPS enables a collection of continuous location and time information for outdoor maps (Zheng *et al.*, 2009). An average of 54% of active users practice mobile online mapping and navigation services compared to paper maps (Goodchild, 2007). As tracking accuracy is to become replicated within Indoor GPS (GIPS), although there is no current standard system (Jung, 2016). GIPS requires installing node devices; Wi-Fi, Bluetooth beacons or dead-reckoning that localise with mobile sensors such as RFID or QT tags (Han and Lee, 2016). Ramirez and Dyrks (2010) contend that this use of this digital mapping aligned with a user wayfinding expectation in real-time, affording as critically crucial to user expectations.

GIS seeks for key features allocated to personalise an area (Teixeira, 2016). It is revealing 'patterns, trends, associations' automating how users can search their destination (Shaw *et al.*, 2008). From 3 million registered 'Open-Space-Mapping' users have contributed to an estimated 5 billion GPS points where geotagged data vigorously increased from 2005 to 2016, using this concept of 'crowdsourcing' (Ma *et al.* 2015). While flexibility and agilities emphasised, 700,000 records every minute from devices is collected (Fox and Chang, 2015); therefore, it is no longer a necessity to predict user needs. It appears location-based services have become robust; for example, the gaming sector revolutionised with *Pokémon Go* and Poke-stops submitted from where users go globally. Montero *et al.*, (2019) states Pokémon's geographic classification to an area 'adds depth', from immersing augmented reality, visual space overlaps real-world space. However, since increased specialisation in DW is controlled by how personal purpose affects a cognitive representation of place (Hartig *et al.*, 2003), controversies are surrounding the diminishing physical salience (Hartley and Burgess 2002; Park and Evans; 2017; Dalton et al., 2019). While, the accessibility of 'hidden logic' afforded from universal systems (Gibson, 2009) should decrease the demand for DW.

## DIGITAL WAYFINDING CONTROVERSY

There is a consensus in research that wayfinding cannot innovate its systems into DW since it effects user orientation 'relative to the distal environment' (Dalton *et al.*, 2019) or in other words, a user's spatial decision-making to navigating space. Several environmental phycologists (Park and Evans; 2017; Dalton et al., 2019) identify DW lacks meeting user legibility particularly, sensory cues from the environment and disconnects the physical, social communication found relevant to user wayfinding. Park and Evans (2017) reasons, a loss of 'physical sense of scale' removes the spatial cognitive process that enables users to recognise a location. According to Hartley and Burgess (2002), users who navigate 'head down' via smartphones are isolated from landmarks to create memorable images without privileging a location known as, allocentric. Hence, the *Legible Cities Movement (LCM)* started in the *1990s* developed the public-information boards holding local maps (Kelly, 2001). Created to support user 'mental maps' and subsequently have moved into an iconic global movement (Kelly and Kelly 2003; SEGD 2007) due to its benefits above.

Although, proponents of DW state that this disregards the conditions to differentiated styles of learning spatial perceptions and knowledge required to meet user legibility (Wang and Shen, 2012). Firstly, Hirtle and Srinivas (2010) states current wayfinding's lack of engagement from end-users and their requirements, questions the arbitrary decision making behind the signs. For instance; estimated, 50 specialists per local city are part of each LCM project yet, 'legibility' defines as best chosen when both; users and professionals combine to input the characteristics of sorted signs (Malgieri and Comandé, 2017). Secondly, static means in physical wayfinding signs also have failed in meeting the built environment reforming conditions in 'real-

time' (Cabinet, 2010). UK government 2011, coalition, estimates to reduce 20% in capital cost by the built environment growing digital exponentially (Blackwell, 2012). Therefore, strategising, according to the growing expectations by users, DW offers opportunities to align with user practical needs and needs relating to their identity.

As DW initiatives have fuelled research (Apelt *et al.*, 2007), they are also lying uncertainties that DW "detaches the user from the environment" (Park and Evans; 2017). This questions whether automatic mapping directions would filter out a correct impression for users within hospitals and cannot guarantee legible location awareness, against conventional wayfinding systems adopted by Lynch (1960). Nevertheless, the growing debate played by DW in providing legible wayfinding, but its high informality, has contributed to advance research to look beyond DW characteristics (Symonds, 2017; Jeffery, 2017; Park and Evans, 2018). Jeffery (2017) argues a symbiosis between physical and digital information into transverse environments, as inevitable. Park and Evans (2018) directly critics the needs to research to delve into triangulating activity pattern between the space, user and digital influence with spatial cognition. They posit that in a world in which digital information is increasingly available there is a greater exploration that is needed to eliminate a continuing compromise made to the user experience; thus, detrimental equity loss.

Linkages among contemporary wayfinding into DW remains undetermined and consequently, this paper follows with the impacts on, and implications of, user performance alongside increasing DW use in hospital systems.

## LYNCH'S THEORY TO HOSPITAL SYSTEMS

According to the Department of Health (2005) publication, hospital facilities were and are committed to aligning effective wayfinding; changing wayfinding with the NHS, created in 1991 and thus, replacing wayfinding standards from the 1984 edition. Today the NHS England matures health as a social movement – "help shift power to patients and citizens" (NHS, 2016) and patient-centric care forward view, 2020, although, to date, no new changes to wayfinding suggested. As a public necessity, NHS is in a current reformation seeking a holistic approach to patient needs (Moore, 2013). Primarily, since patient social issues such as stress, anxiety and apprehension beyond physical wellness, Cheng and White (2018) state it to affect the recurrence or length of a condition. Therefore before exploring ways of innovating hospital systems, it is necessary, to understand a hospitals systems responsibility of linking hospital users with space, using Lynch's (1960) Theory of a good city form. Short *et al*., (2019) identified analysing the hospital systems performance mechanisms in planning theory, will validate durable criteria, expressly, human values with space, to innovate from

The framework contains 2 gaging cues of linking space to users (Lynch, 1960). The formal components: *identity* "to differentiate one space from another" and *structure* "the object that is placed in the space, in relation to the observer and to other objects" (ibid) both, referring to seek hospital systems physical elements and functional positioning. However, hospitals strict hygiene requirements imply near-identical corridors, lacking distinctiveness and minimum ornamentation. Instead, colours and specific signs are coordinated to inform users (Short et al., 2017) yet the terminological identifiers, lack user responsiveness. Aspiring for practical usability through a sorted network, the collective user objectives might differ from user preferences, as evolving needs might be difficult to individually monitor. Whereby meaning, Lynch (1960) states "is that which the place stands for or represents" based on user needs to hold systems accountable. This type of sensory cues appears relative to DW uses.

While the informal components although the literature are limited, Lynch (1960) claims "none of these… are absolute desiderata". These type of sensory requirements characterise DW as it uncovers individual spatial behaviour – combining socio-cultural and mobility (Alessandretti et al., 2018) affording to a user's

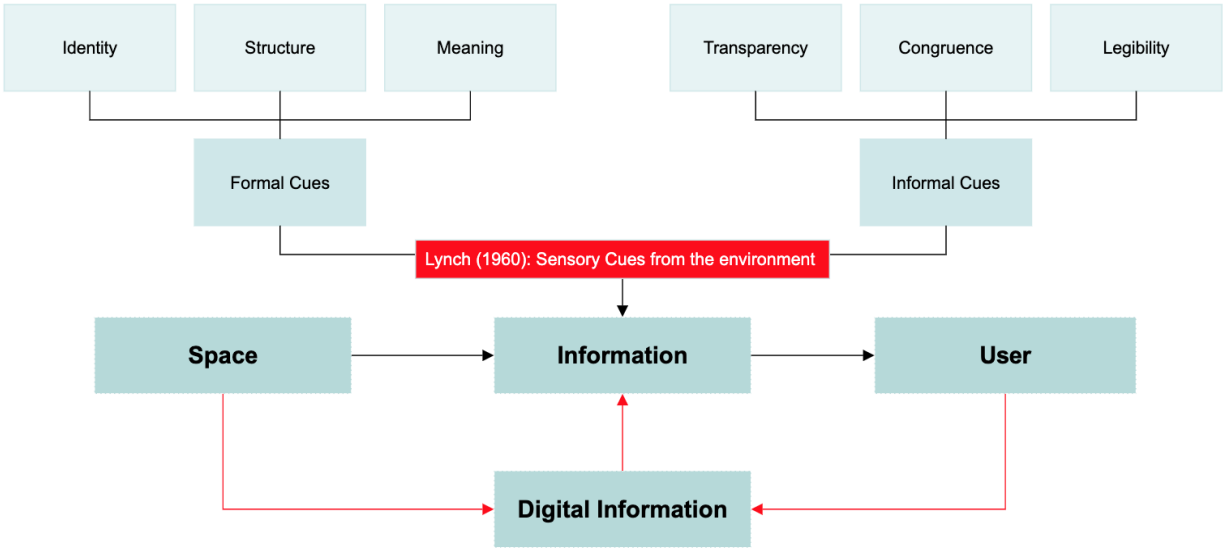
frame of reference and desires. What is transparent and congruence relates to individual patterns that vary in 'attachment, warmth, relaxation and interest' (Lynch, 1960). To outline, the fatigue in hospital systems is listed as the top from users and inequity has lost £108 for every 6.9 million missed outpatient appointments in UK NHS, 2012/13 (NHS, 2014). Both demonstrate that those users own spatial experiences were not 'rooted' in the network. Bound to the user's observation, legibility is emphasised as the most important (Lynch, 1960). For example, hospital systems lack of congruence imply the users to not feel, at the time, freely open to awareness, thus cannot corroborate spatial cognition. Overall, it is clear for symbiosis in information all Lynch's cues must factor valuable to ensure optimal delivery of hospital space.

## INTEGRATING DW WITH HOSPITAL SYSTEMS

As it stands, hospital systems link people with space by sorting from formal sensory cues. Using hospital 'hidden logic' according to Jeffery (2017) in 2.2 and signs are remaining as efforts positioned by other people (Dalton et al., 2019). Information and refinement begin with, "landmark knowledge, then route knowledge and finally survey/map knowledge" (Lingwood et al., 2015; Mondschein and Moga, 2019), mirroring Lynches cue's. Thus, healthcare logic is reliant on curating users 'cognitive maps' to make meaning. However, when cognitive difficulties amidst, it commonly derives from mental stresses including anxiety, typical to a hospital setting, thus cause symptoms of "attention, memory and reaction time" being affected (Cockshell and Mathias, 2010). These informal patterns have risen to equity loss from late or missed arrival to outpatient appointments or inpatient admissions; the strain on healthcare provider time to guide lost individuals (Martins and Vasconcelos de Melo, 2014); also junior doctors getting lost during urgent crash calls (Brown et al., 2015). Where a hospital mission seeks to bring power to its users, it shows this has not been possible with universal reasons.

In recent years, demands for enhancing user need have been acknowledged. Conclusions from Cooper (2010) and McCullough (2009) state that 1,000 research studies recognised, improving a healthcare facility design can decrease medical errors, waste and financial losses. This has led to a high volume of advanced DW solutions to meet the demand (Smith, 2017), automating personalised location-based services (Tham *et al.*, 2013) and enriching spatial knowledge via multi-attribute systems (Hirtle and Srinivas, 2010). However, an information dilemma has risen, where signs expound from the choice of information "upon the embodied wayfinding experience" (Symonds, 2017). Mollerup (2008) found that hospitals remain to offer 'more signage' to tailor to users. At this point, the implication shows causing the quantity of information to be overwhelming (Copper and Smith, 2004). For example, personalised engagements including "touch-down menus that allow people to send the map to their smartphones" and "dynamic data such as 'doctor bio' added to kiosks" (Lorenzi, 2018). The layers of data are intimate; however, can also expound an information overload of options disorientating users (Kim *et al*., 2015) and reasonably identified as a filtered failure (Asay, 2009). It appears DW informs users with identity choices in route but not legible quality, *figure 2.*

***Figure 2:*** Input remains salient from catagorised choices, however what is made available for users decreases the amount of option of output to what users can understand. Adapted by Lynch (1960).




However so far, the rising of DW relates to information overload as another taxonomy problem and to now, finding a symbiosis to innovate hospital systems with DW has remained challenging. Joshua Titus, CEO of Gozio Health (2018) states the challenge of hospitals systems appears not technical, instead the "innovation is not embraced by hospital culture". Through the lens of *The Critical Theory of Technology* (Feenberg, 2005) it demonstrates technology has two points of view: how the technology is designed and how it is used (ibid). This engagement theory has provided a useful starting point to explore the use of DW and exploration of behaviours (Lorenzoni *et al.*, 2007; Whitmarsh and O'Neil, 2011). Interpreting the position of Feenberg (2005), technology from an economic standpoint must be coherently humanised in a social setting that it will be placed in. This approach shows hospitals sorting into formal cues remain to use static strategies with one-way communication, withdrawing an interactive experience required under complex and time-sensitive pressures. Delving into this theory, the concern is not the technology but instead, the system concerning user performance. Although limited research has explored whether there is this structural problem in the system affecting DW continuing.

## INNOVATING HOSPITAL SYSTEMS WITH DW

Attempts at finding a symbiosis to innovate hospital systems with DW have remained challenged. Although research from other disciplines specifically, Amazon and Disney it is evident a symbiosis between physical and digital to be possible. Amazon alongside other retailers (Macy's. Walmart and New Balance) use a 'chaotic storage model' (Reichardt 2011) used in warehouses via an automatic picking system that knows where and when to go. With asset tracking capabilities through an interactive map, each asset can be displayed on a map. Thus the robot is supported by an interactive floor (in this case RFID tags) to navigate to where it is (Batt and Gallino, 2017). In comparison to a hospital system, since the research phenomenon involves ways to improving the experience, the concept of 'chaotic storage' can be used with locations, user destinations can be displayed on an interactive map then, users navigate with an interactive floor.

At Waltz Disney World Resort *'MagicBands'* provide a system that connects data to the guest and all the facilities tailored to what they require (Barnes, 2014). Including but not limited to; hotel keys, tickets, photo pass and payments. As part of the next generation experience, the RFID wristband is located at key entry park points and interacts within rides or queues the victors enter. Connected with the Waltz Disney experience GPS-enabled app combined, supports a symbiosis experience required (ibid). Borkowski *et al.*,

(2016), identifies Disney's success to customise a personalised and memorable touch in the experience where using "IT to serve a customer-centric business model". Both examples demonstrate viewed from the user/robot position and using DW to ***'search'*** rather than be ***'sorted'*** into the physical sensory cues at their disposal. Thus, it has tackled journey planning to optimise the user experience to search for their needs prior.

The captivation lies in the nexus between contemporary planning of wayfinding and the human control of effect by the system and dependencies on uses as users immerse with wayfinding in new environments. Both Amazon and Disney share two conclusions: they both identify, removal of predicting user information alongside a user to be 'wholly implicated in its milieu' (Gatens, 2004). Thrift (2010) observed something similar where objects 'involved in multiple overlapping negotiations with human beings and not just as a set of passive and inanimate properties. It may also include viewing Lynch's sensory cues from the informal cues to formal cues to play as a key role in effectively innovating with DW. As Seigworth and Gregg (2010) condone the effect is "in the capacities to act and be acted upon". However, the applicability of these findings for hospital systems faces a critical limitation; here, the issues reflect DW between hospital system user performance and space with DW posited by the composed method as mentioned above.

## FRAMEWORK FOR DIGITAL WAYFINDING RESEARCH

Till now, there have been an intellectual cross-currents of literature. Although disparate, presents a nuanced picture of how digital revolutions and spatial experience can help address a well-established humanistic need in planning. Challenged by the traditional methods to categories by sorting and refining information appropriate to cognitive mapping; opposes the personalised user expectations from the broader social objectives, within a complex, diverse city. These insights from Lynch's Theory (1960) extend to scholars analysing innovation using automated, randomised and accurate opportunities to optimise a tailored-led approach. However, how these processes can best optimise or rather innovate, a user performance plus experience and in what ways to structure the system for user efficiently, are open questions. The degree of user perception of control over the space must be cultivated with planners in a digital age, requires revising. It is proposed a critical analysis to consider the introduction of the *searching* factors to be examined for information and refinement.

Using the Lynches Theory (1960) in a digital age, some assumptions can be made from the way it can materialise. This adapted wayfinding model compliments information to be taken from both digital and physical sensory cues. The symbiosis facilitates from social-cultural needs for user-centred behaviour, and engaging in active spatial learning contributes to its development. As theory identifies there is a people value aimed at personalisation over their environment and the lack of current preferences input may alienate and disconnect users from their surroundings. It was identified Feebergy critical theory (2005) of technology is grounded "to conceptualize such subjects position in relation to the materiality of technology and by extension, data". In other words, the hospital system grounded by the purpose of the hospital norms lacks how it was used in 'actual' means within the world.

## CONCLUSION AND FUTURE RESEARCH

This research framework and tools sought to explore the impact and implications of user performance within a growing DW field in hospital systems. While the growth of DW field has led to divided views on their efficiency with user performance and having the potential to expand, this challenges a symbiosis between wayfinding's physical and digital information systems. Although, contemporary planning within hospital systems examined herein, presses continuing concerns about a gap between a universal system, inspired by Kevin Lynch and incorporating personalised needs. The scope of work establishes people perceptions of spatial organisation outlines a greater value to how wayfinding is effective today. Further, the paper outlines, the sensory cues linking hospital systems remain contemporary through sorting signs thus, to users it appears

these predictions are hampered and elude the issue for automating user needs through a hypothesised searching method.

Future research would benefit from extending from this searching model of wayfinding to additional indoor wayfinding planning, extensively across other areas in hospital systems. While Lynch's insistence of a good city form shows, collective efforts made in participation to combine all user's, is an important contribution. Today's societal and technological changes require wayfinding to recognise the needs of exploring how can systems react individually and universally? And requires research to delve further into identifying areas of concern in wayfinding systems that re-contextualises the datasets within the system structures. Like Amazon and Disney's searching approach, wayfinding could yield improvements in public health, thus user performance. At the same time, they signal the pre-conditions critical to a diverse set of bodies. Effect different abilities and predispositions to safely navigate; be heard and identified amongst the myriad public of today. Each unique user needs require preferences for digital and physical information systems to be available as seamless as possible. Ultimately hospital system must reconsider how DW can heighten user control for their populace.

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