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5	Location	United States (US)
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7	Summary of evidence	Analyzing Walkability Through Biometrics: Insights Into Sustainable Transportation Through the Use of Eye-Tracking Emulation Software Understanding more about the unseen side of our responses to visual stimuli offers a powerful new tool for transportation planning. Traditional transportation planning tends to focus on the mobility of vehicles rather than on opportunities to encourage sustainable transport modes, like walking. Using eye-tracking emulation software, this study measured the unconscious visual responses people have to designs and layouts in new built environments, focusing on what makes streets most walkable. The study found key differences between the way the brain takes in conventional automobile-oriented residential developments versus new urbanist layouts, with the former lacking key fixation points. The study's discoveries significantly explain why new urbanist layouts promote walking effortlessly and conventional automobile-oriented residential developments cannot. https://journals.humankinetics.com/view/journals/jpah/17/11/article-p1153.xml

8	Please select which exposure(s) your evidence relates to. Further explanation on these exposures can be found on a PDF file here. Please select all that apply.	Planning (e.g. density, green spaces, housing, transport, urban design etc.)
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Human Kinetics
ORIGINAL RESEARCH

Analyzing Walkability Through Biometrics: Insights Into Sustainable Transportation Through the Use of Eye-Tracking Emulation Software

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Background: Understanding more about the unseen side of our responses to visual stimuli offers a powerful new tool for transportation planning. Traditional transportation planning tends to focus on the mobility of vehicles rather than on opportunities to encourage sustainable transport modes, like walking. **Methods**: Using eye-tracking emulation software, this study measured the unconscious visual responses people have to designs and layouts in new built environments, focusing on what makes streets most walkable. **Results**: The study found key differences between the way the brain takes in conventional automobile-oriented residential developments versus new urbanist layouts, with the former lacking key fixation points. **Conclusion**: The study's discoveries significantly explain why new urbanist layouts promote walking effortlessly and conventional automobile-oriented residential developments cannot.

Keywords: cognition, human behavior, planning, new urbanism, psychology

Traditional transportation planning tends to focus on the mobility of vehicles rather than on opportunities to encourage the use of sustainable transport modes, like walking. Today, transportation planning focuses on the newest ways to balance the sustainable relationship between human beings and the livable environment. This includes ways to reduce unnecessary transportation use and to increase pedestrian walkability in communities. We are now living in a new age of biology in which new findings in cognitive science, coupled with new biometric tools, can help us better understand human behavior. Technologies such as electroencephalography, which measures brain waves; facial expression analysis software, which follows our changing expressions; and eye-tracking software, which allows us to record unconscious eye movements, all provide information about how our brain takes in our surroundings and directs our behavior.[1–3] These technologies are widely used to create advertising, packaging, computers, and other products in our world today[4–6] but remain relatively unknown and untested in the fields of architecture and transportation planning. Eye tracking is a technology that has been widely used in graphic design to measure the allocation of visual attention over a visual stimulus.[4–6] In this study, we explore eye tracking's usefulness in assessing a new residential real estate development, designed to promote sustainability and healthy living.

Lynch[7] declared that there are inherent benefits to pedestrians in creating well-defined and clearly expressed edge conditions in urban environments. While the environmental psychology literature is rich with evidence about ideal street widths, signage, lighting, signaling, and landscaping, this study is one of the first to show how biometric tools can increase our understanding of how people respond to the places around them while driving and walking (other studies that have begun to use these biometric approaches include Hollander et al,[2] Hollander et al,[8] and Noland et al[3]). In addition environmental design, the importance of certain design characteristics to encourage walking have been suggested in urban design theory.[9] It provides new data on hidden, unseen experiences that determine human behavior. This information turns out to be germane to helping us better understand remarkably specific things, such as how confusing someone might find signage on an unfamiliar street and how likely it would be for a visitor to walk down a sidewalk in a new neighborhood.

For this study, we used a relatively new off-the-shelf biometric tool, 3M's Visual Attention Software (VAS), introduced in 2011.[10] This technology emulates eye-tracking techniques and was used to measure the unconscious visual responses people make when presented with the various designs and layouts in Devens neighborhoods; Devens is located nearly 35 miles west of Boston and is undergoing redevelopment. The results suggest new parameters for quantifying the human experience of the built environment and provide a means of both assessing and predicting the human experience of place. This could help create new neighborhoods that more successfully respond to intrinsic human needs with regard to walking and driving so as to increase pedestrian walkability and to reduce the use of driving and other unsustainable modes of transportation in communities.

Literature Review

Eye Tracking

Eye tracking has been widely used in graphic design and other computer-based evaluations to measure the allocation of visual attention over a visual stimulus.[4–6] In general, eye tracking evaluates the movement of the eyes as a person gathers information from a scene; the eyes tend to fixate (focus) momentarily in a particular scene area and then move via a saccade to the next fixation point. Patterns of saccades and fixations are influenced by both internal states, such as mental workload, frustration, and uncertainty, and external states, such as the salience and organization of a stimulus. As interest in a stimulus increases, the eye tends to fixate more (ie, increased fixation count) and for longer durations (ie, increased fixation duration), and blinks are reduced (ie, reduced blink count) and truncated (ie, reduced blink

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duration). Furthermore, saccade duration (ie, higher amplitude) and overall scanpath length may change due to a desire to explore more or less of an image. Researchers studying decision support systems (computer-based visual tools to aid in decision making) used the visual information from eye tracking in one recent study to assess ecosystem services.[11] They found that certain visual features of such a decision support system could improve users' ability to understand ecosystem services, as measured by eye tracking. Others have explored the ways that people perceive landscapes,[12–14] focusing on fixations, saccade amplitudes, blink rates, and gaze paths. A broad overview of eye-tracking literature has recently been produced by Kiefer et al,[15] providing an assessment of the challenges and opportunities for eye tracking in the fields of spatial cognition, geographic information science cartography, and related fields.

Additional studies have investigated eye tracking in a host of ways in the built environment. Torralba et al[16] used a contextual guidance model with a Bayesian framework to predict image region fixations by observers when searching for specific objects, such as pedestrians, paintings, and mugs, in both indoor and outdoor scenes. Ehinger et al[17] likewise asked participants to search for pedestrians in the built environment, applying multiple models to predict fixations for pictures, with and without pedestrians present. Eye tracking has also been investigated as subjects conduct orientation and self-localization tasks when assisted by mapping applications utilizing geographic information science software.[15] Results showed that successful participants more frequently switched between viewing landmarks in their environment and corresponding map symbols and spent more visual attention on objects that provided helpful clues. And Hollander et al[2] employed a combination of eye tracking and surveys to assess subjects' emotional connections with varying urban scenes.

Auffrey and Hildebrandt[18] used 3M's VAS to predict sign visibility to passing motorists in lieu of eye-tracking camera and on-site tests, which are expensive and time intensive. In Ahn and Kim's study, VAS was used to validate the efficacy of tactical urbanism in order to improve pedestrian safety. Yellow pavement was placed near pedestrian crossings to make crossings more visible to drivers. With VAS, researchers were able to determine that the yellow pavement was subconsciously fascinating, which explained pedestrians increased visibility.[19]

Encouraging Walking: An Unconscious View

Researchers have long noted that places implicitly invite or do not invite walkability. Kevin Lynch declared the inherent benefit to pedestrians in creating well-defined and clearly expressed edge conditions in urban environments: that people would enjoy spaces in which such edges existed and would return to them.[7] Alexander et al[20] followed with their own seminal pattern language—towns, buildings, construction—in highlighting the importance of edges and facades for creating welcoming and inviting places that people would find pleasant to visit. A more recent seminal book on urban design, Gehl's *Cities for People*, reinforces this same point, suggesting that these high-quality edge conditions, and well-designed facades in particular, help invite visitors and create highly desired public spaces.[21] Despite the consensus, none of these authors demonstrated that façade design actually influences people or provided empirical evidence for why edges are so important.

Sussman and Hollander[22] argued that human preference for edges (wall hugging or thigmotaxis) is part of our evolutionary heritage. Wall hugging here means the unconscious impulse to maneuver around one's environment with close, tactile connections to walls or edges. Thigmotaxis is a Greek word that means "touch" and has been widely used by biologists as a technical term for wall hugging. Many species exhibit the behavior, from paramecium[23] to earthworms,[24] frogs,[25] and snakes.[26] The behavior is also related to the edge effect. *Edge* is the landscape ecology term for an abrupt transition between 2 biological communities or between environment/landscape that creates distinct habitat boundaries.[27] These edge environments are associated with habitat fragmentation and typically attract a higher diversity of species. For example, edge species like deer prefer to live between forest and lands or riparian zones, because edge environments have an abundance of food and cover.[28] Most research on thigmotaxis has focused on nonhuman animals, but recent evidence suggests that humans prefer edges as well. In one study, Kallai et al[29] found the presence of the thigmotaxis trait in humans based on studies conducted on human movement along corridors.

While edges are generally preferred in the built environment, not all edges are created equal. Ewing et al[9] sought to quantify the best streetscapes by counting pedestrian activity and found that the busiest places also had active uses, street furniture, and permeable edges (windows on the ground floor). Sussman and Hollander[22] argued that there are 3 features that influence the quality of an urban edge focus largely around facades: (1) permeable walls (doors, windows, and arches); (2) varied materials (changing every 30–50 ft); and (3) overhanging features (awnings). The US Green Building Council's Leadership in Energy and Environmental Design for Neighborhood Development rating system's Neighborhood Pattern and Design credit category also incorporates these elements to promote walkability and pedestrian-scale design.[30]

Other scholars have more broadly examined exteriors of buildings and their role in emotional responses. Nasar[31] set up a useful framework by suggesting 3 major categories of building exterior qualities: enclosure, complexity, and order—a nonevolutionary view of how people experience places, grounded on empirical observations of psychologists. Many of those studies were executed by Kaplan and Kaplan,[32] who in their 1983 book offered numerous other competing conceptual frameworks and evaluative categories for assessing exteriors (edges included). Likewise, that work sees edges solely through the mind of the observer and lacks theoretical grounding in evolutionary science, whereby this study is oriented around a unique set of characteristics of edges—a test of this new perspective on environmental design.

Outside of the environmental design world, urban design theory has long suggested the importance of certain design characteristics to encourage walking,[9] but no work has empirically tested this question. The goal of this paper is to begin to explore how urban form influences walkability so as to learn how to encourage walking instead of driving via unconscious interventions of the built environment. The question we raise for this study is, what does eye-tracking emulation software reveal about the qualities of places to support walking?

Methodology

Research Area

Devens is a 4400-acre former military base approximately 35 miles west of Boston that is undergoing redevelopment. It is surrounded by several communities with a variety of urban and suburban forms, including traditional village centers and newer automobile-oriented residential subdivisions. What sets Devens apart from other military base redevelopments is its focus on sustainable community redevelopment and its ecoindustrial park approach, having firms collaborate to share information and resources in order to maximize efficiencies and minimize waste, mirroring a natural ecosystem. As a regional enterprise zone, the redevelopment of Devens stood on a solid reuse plan and a sound economic development strategy. To create a truly sustainable community, Devens realized it needed to also create opportunities for people to live, work, play, and learn. Guided by the principles of sustainability, the redevelopment of Devens to date has attracted over 100 organizations, created over 5000 jobs, and permanently protected over 1400 acres of open space.[33]

Sustainability in Devens has been defined as: "the thoughtful and careful redevelopment of the base for the purpose of promoting economic development, social welfare, environmental protection, and natural resources."[34] To facilitate sustainable approaches to residential development, in 2013 the Devens Enterprise Commission, the permitting and regulatory authority overseeing redevelopment, drafted and adopted new innovative residential development regulations designed to promote healthy, energy-efficient, complete, connected, and accessible neighborhoods that put people first and foremost. Since the passage of these regulations, a 124-unit residential development on Chance Street was approved with a mix of single-family and 2-family homes, townhomes, and apartment buildings. Chance Street combines cluster subdivision concepts with new urbanist principles in which compact and highly energy-efficient homes frame the street, creating a pedestrian-scale and socially engaging neighborhood and streetscape.

Data Collection

This study focused on several areas within Devens and in surrounding communities, in which the research team spent several days over the course of 18 months photographing over 100 locations (see Figure 1 for the locations in which photos were taken). We used a stratified sampling method to ensure collection of a minimum of 10 photos from several new real estate development projects, recent renovation projects, and older buildings on the former military base. Because the Devens Enterprise Commission purposefully intended for Chance Street to have a pedestrian-scale and a socially engaging streetscape, we were sure to include Chance Street to observe whether this newly built neighborhood increased perceived pedestrian walkability, considering its architectural façade. For comparative purposes, we also photographed areas outside of Devens, again using a stratified sampling method by collecting a minimum of 10 photos from each of 2 types of project: a historic downtown and business center and conventional housing developments.[I] Conventional developments in the postwar period were characterized by Mumford[35] as "a multitude of uniform, unidentifiable houses, lined up inflexibly, at uniform distances, on uniform roads." Earlier construction forms of suburban housing focused more on separating vehicles from pedestrians[36]; post–World War II housing patterns featured garage-dominated facades, which hindered residents from encountering their neighbors.[37]

Photo Inventory

The first step of this study was to create a photo inventory for Devens. Beginning with the newly constructed houses on Chance

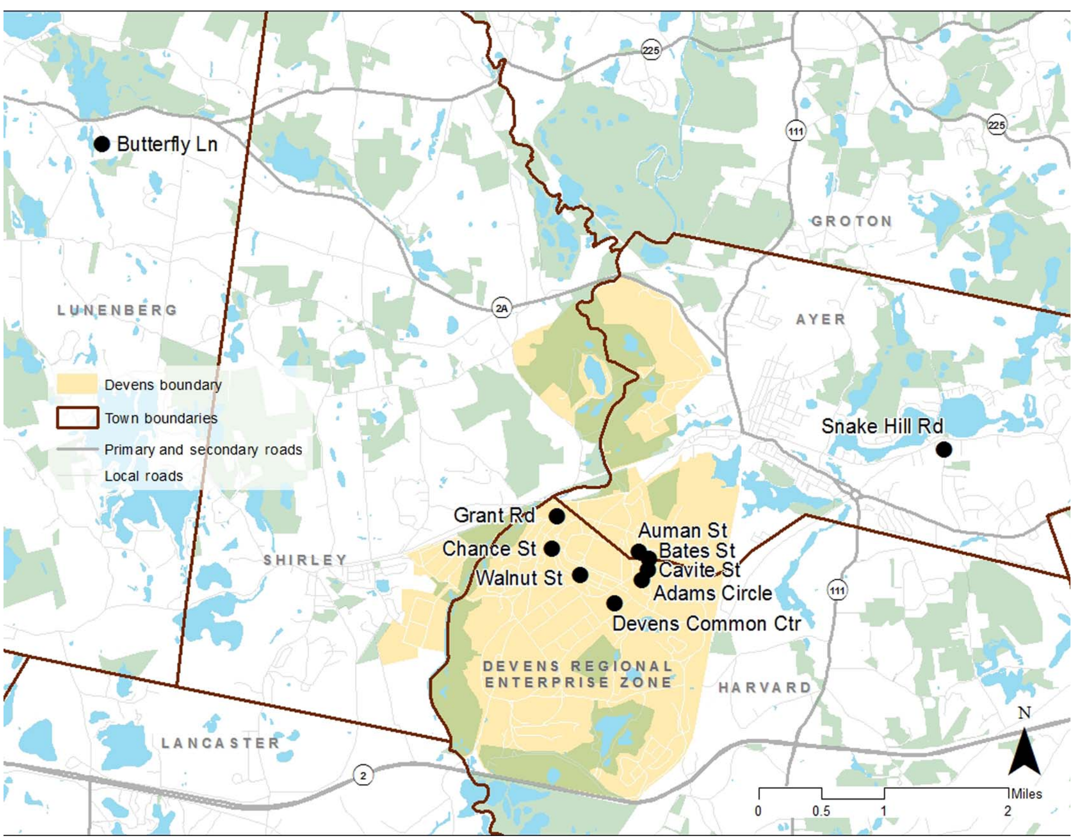

Figure 1 — Devens location map.

Street and restored and unrestored buildings in the Devens historic district, then moving on to older officer housing on Walnut, Auman, Bates and the Vicksburg Square former barracks complex on Buena Vista Street, and more recently built net-zero energy residences on Cavite Road and Adams Circle. The historic downtown and business center selected was in neighboring Ayer, Massachusetts, and the conventional housing developments (we identified 2 substantially sized ones) were on Snake Hill Road in Ayer, Massachusetts (built since 2000) and on Butterfly Lane, in Lunenburg, Massachusetts, built within the last 5 years. In total, we collected 228 images from Devens and the surrounding towns.

Buildings were all photographed using a standard framing and perspective. Each photographer was instructed to stand "at the side of a curb, aiming a camera across the street, angled so as to capture as much as possible of the facade of the building opposite from a distance of 5–12 m." The images were all captured at a minimum resolution of 300 dpi.[38,II]

Analysis

The second step of the study was the analysis of the images, for which we used 3M's VAS, which emulates eye tracking, a biometric tool that maps the path the human eye takes when looking at something.[10] The software employs decades of previous lab-based eye-tracking analysis to refine an algorithm that is used to predict what people would be expected to focus their eyes on in an image. 3M's VAS was developed primarily for use in marketing and signage placement.[39] Companies such as Clorox, Unilever, and Anheuser-Busch use VAS to aid in designing commercial products ("VAS in your workflow"). Since VAS has been on the market, it has been utilized to measure the attractiveness of various packaging designs,[40] to analyze the effectiveness of roadside signage on motorists,[18] and to optimize the placement of advertisements on a busy page.[41] No published research to date, however, has applied VAS to better understand the human experience of architecture and urban planning or place.

Understanding where we look without conscious awareness—at "first-glance," as 3M notes[10]—turns out to be supremely important for determining our subsequent behaviors. Neurons that carry the information from our eyes go directly to our brainstem, our ancient reptilian brain, at the ready to fight, flee, or freeze depending on information received. This bottom-up processing, which happens first and faster than the top-down thinking from the higher human cortical regions, makes VAS and eye tracking so relevant as a predictive metric for gauging human behavior in the built environment.

Eye tracking records fixations, or resting points, and saccades, the rapid movements between them, and can give insight into what features of an image immediately attract attention. Traditional eye-tracking studies use a lab setup requiring 30 or more test-takers per study and can be costly and time-consuming to complete. We selected the web-based 3M product, which provides useful (though not as robust) results and is infinitely easier, cheaper, and more efficient to run.[18,40]

Visual Attention Software's algorithm is based on 30 years of eye-tracking research and predicts human responses to visual stimuli within the first 3 to 5 seconds, or during preattentive processing (before our conscious brain can get into the act). It assesses study images for 5 visual elements known to attract human attention: edges, faces, color intensity, red/green color contrast, and blue/yellow color contrast.[10]

The data that VAS creates for each image appears as compelling graphic representations, which are typical eye-tracking output. These include heat maps, which glow reddest and brightest where people look most; visual sequence diagrams, which track the most likely path eyes take in looking at a scene; and regions of interest (also known as areas of interest) diagrams, which delineate the areas that draw the most attention relative to those that draw less and no attention with simple enclosed lines. The software creates all these quickly, in under a minute, once an image is uploaded to the 3M site.

Quantitative Analysis

The third step of the study was to explore how the findings held across the neighborhoods studied; we ran a quantitative analysis tabulating first fixations and strongest regions of interest, or areas that show up in red outlines in VAS, indicating a 70% to 96% chance of drawing a person's attention in the first 3 to 5 seconds (VAS uses this 3–5 s preattentive period to reflect the expected unconscious response people might have to an image). We limited the sample of photos to those with a building comprising at least 10% of the image. For red regions, we counted the single feature most predominately featured.

Results/Findings

For residential subdivision design, the study indicates that housing designed with punched windows and porch columns tends to attract the eye. In addition, people ignore blank facades and are less likely to look at blank elevations or move towards them. The scanpaths (visual sequence diagrams) forecast the path the eye will likely follow as it fixates or rests (for several 100 ms at a time) on different elements in a scene or image (Figures 2 and 3).

The pedestrian-oriented design of the neighborhood on Chance Street created edge conditions with requisite fixation points for pedestrians to focus on at their side to enable walking forward effortlessly (Figure 4). The VAS results for Chance Street show the regions that grab human attention first and most (in red outline)—and how they tend to be at the street edge, not straight out front.

The study also reveals a key reason why conventional development hampers walkability. Development fragments unconscious visual sequencing, making it hard for people to know intuitively where to move. Walking bipedally, a demanding activity for the brain, is best done with automaticity, without the brain having to consciously think about it; this happens more readily when layouts

Figure 2 — Visual sequence diagram of Chance Street in Devens.

provide sequential arrangements of fixations. Sidewalks also provide a clear path designed for pedestrians, in contrast to conventional subdivisions with roads for cars.

The results from conventional subdivisions, such as those in Lunenburg and Ayer, reveal that conventional subdivisions make people focus preattentively on the horizon and distant view (Figure 5A and 5B); VAS indicates that in conventional developments, such as Snake Hill Road in Ayer or Butterfly Lane in Lunenburg, people relentlessly look, or fixate, straight ahead. They simply cannot help themselves; the brain directs this behavior without conscious awareness. The houses are simply set too far back from the street to get the brain's initial attention.[III]

The study also suggests that walkable neighborhoods, with short block lengths and a sense of enclosure, consistently connect buildings, streets, and the pedestrian's point of view, while conventional subdivisions do not. Subdivision building front doors, set far back from the street, lead to driveways rather than streets and are inadvertently blind to pedestrian orientation needs. In Snake Hill Road (Figure 6), VAS heat maps show this disconnect between the street and the residence as a large black band, severing the viewer from the building and deconstructing the way in which the pedestrian sense of disconnection happens.

Our findings indicate that the layout of conventional subdivisions, such as those in Lunenburg and Ayer, while obviously taking in the desires of individual homeowners, are designed collectively from a driver's perspective, designed to provide an uninterrupted view of the road straight ahead. A layout with houses far from the street makes it easy on a driver but difficult for a pedestrian walking in the neighborhood to fixate on or even find any buildings preattentively. This makes walking onerous and lessens the likelihood that people will even think of doing so. Essentially, what we appear to observe in this study is the impact of the near-universal application of the American Association of State Highway and Transportation Officials Highway Manual in suburbs. These standards prioritize the needs of drivers and gives little thought to pedestrian experience, walkability, or overall human health. As the concept of complete streets has become more widely accepted and incorporated into revised state road design manuals, this is beginning to change. Unfortunately, local jurisdictions have embedded the American Association of State Highway and Transportation Officials standards into their local subdivision regulations and the local revision process is lugubrious, to say the least. Williams[42] found out that walking can reduce the risks of brain cancer mortality. Thus, creating residential districts in which walking is implicitly difficult, such as car-centric developments, implicitly harms human health.

We saw that visual sequencing forecasts walkability and coherent experience of place. Gaze path matters and appears to connect to ease of orientation in a place and ease of moving oneself forward in that place. Whether in Butterfly Lane or Snake Hill Road, we experienced a sense of disorientation when visiting these

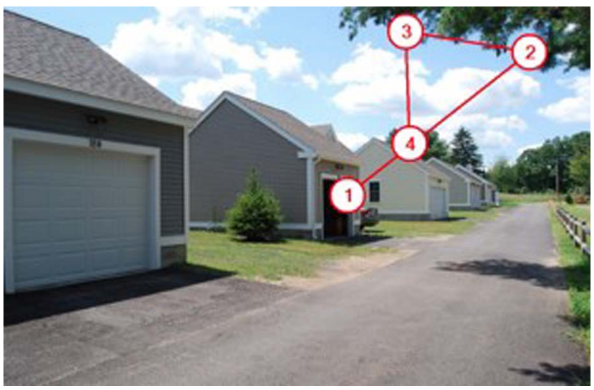

Figure 3 — Visual sequence diagram of garages off of Chance Street in Devens.

Figure 4 — Original photographs (left) and regions of interest diagrams (right) of Chance Street, which grab the attention.

Figure 5 — (A) Original and regions of interest diagrams of Butterfly Lane, Lunenburg. (B) Original and regions of interest diagrams of Snake Hill Road, Ayer.

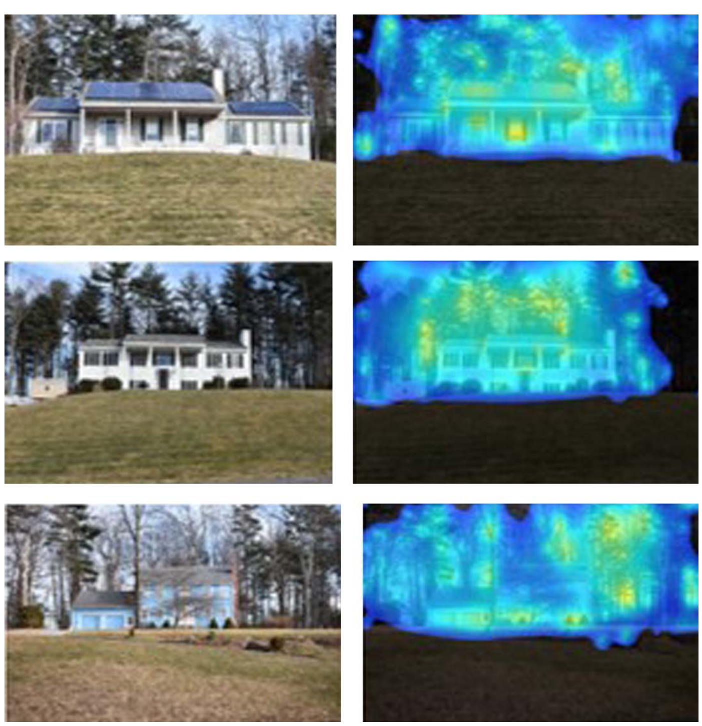

Figure 6 — Original and heat maps of Snake Hill Road in Ayer, which create black bands of inattentiveness between the street and the building.

conventional subdivisions, and the VAS visual sequencing, starting up in the air or on a tree, suggests why. Conversely, we experienced a sense of coherence in the areas with the most straightforward gaze path, with VAS focused on houses, front porches, symmetrical arrangements of punched windows, and doorways; this was true in the Chance Street development.

Discussion

When we visited Chance Street, it was much easier for us to walk down the street than the parking alley behind the residences. Seeing the fixation paths above can help us better understand why those feelings occurred, and learning about the ways in which unconscious behavior directs conscious activity can also clarify why walking around one area seemed effortless and walking around the other, although it was only a stone's throw away, was much more difficult.

The study also reveals a key reason why conventional development hampers walkability. Development fragments unconscious visual sequencing, making it hard for people to know intuitively where to move. Walking bipedally, a demanding activity for the brain, is best done with automaticity, without the brain having to consciously think about it; this is what most likely happens when layouts provide sequential arrangements of fixations. Sidewalks also provide a clear path designed for pedestrians, in contrast to conventional subdivisions with roads for cars. Thus, layouts that provide sequential arrangements of fixations help the brain avoid consciously thinking about where to move to.

Treating walking as an externality, as we see in this study, promotes a fracturing of the public realm and a disconnected sense of place, resulting in both individual and community social isolation. The primacy of first fixations and how much they matter was also suggested by this research. Interestingly, in the most walkable districts, including the new, urbanist Chance Street and Vicksburg Square along Buena Vista Street, first fixations tend to be on building facades themselves; this rarely happens in conventional developments, in which first fixations are often on roads, the sky, or edge conditions. On Chance Street, we also observed the way in which the fixation sequence, within 5 seconds, connects neighboring buildings, making the neighborhood appear inherently connected. This helps secure us in space, making us feel more connected in a place.

Implications for Transportation Planning

Using eye-tracking emulation software has tremendous potential in transportation planning. Planners can run renderings of their building or street view design through VAS to cheaply and easily learn where fixation points lie in their designs. It could also help identify which areas are noticed and which are overlooked during preattentive processing, which could help planners evaluate the effectiveness of their designs. It could also be used for balancing different needs vis-à-vis drivers and pedestrians. Importantly, the study highlights how human walking needs and automobile driving needs are different, opposing, and, in certain ways, irreconcilable. The driver wants a view straight ahead without distractions at the edges in order to be able to move straight forward quickly; the walker favors edge conditions that draw the eye on a rhythmic, regular basis, like on Chance Street. For example, VAS can help planners measure whether their streetscapes encourage exploration or privacy through walking or driving, depending on the purpose of the development.

The study offers new parameters for quantifying the human experience of the built environment. It can help create new and redeveloped neighborhoods that more successfully respond to intrinsic human needs with regard to walking and driving so as to increase pedestrian walkability and reduce driving.

Limitations

While VAS successfully estimates where we will look in preattentive processing, the software cannot tell us about the emotional character of a person's response or how the buildings or streetscape make us feel. Eye-tracking tools record how long people spend looking at an element and their viewing patterns, not their positive or negative emotional responses. For that critical information, researchers combine eye tracking with other biometrics, including electroencephalography, which measures brain waves and approach avoidance tendencies; facial expression analysis, which actively tracks facial muscle movements; and heart rate monitoring, which can indicate levels of arousal and interest, among other metrics. Researchers also rely on self-report or simply asking lab volunteers how they feel when taking in a stimulus and systematically recording their responses.

The photos were collected in a small area, which limits generalizability. In addition, as commercial software, VAS' inner algorithms is unknown for this study. Further research is needed to expand the geographic scope of the research area in order to improve external validity. Further study should also test the VAS algorithms, perhaps using a similar corpus of images with a laboratory setting of test subjects in order to compare how closely the algorithm predicts real eye gaze on images.

Conclusion

Devens Enterprise Commission aimed to create a walkable neighborhood in Chance Street. Our findings helped them to figure out how to reduce unnecessary transportation uses in their development and to raise pedestrian walkability in the community. Our study shifted the focus from mobility to walkability, which create a new perspective for discovering the human visual perception of transportation needs.

In this study, using emulation software to understand people's travel experience in Devens and its surroundings, several conclusions can be drawn from our findings:

- Fixations drive exploration; this is key for understanding how our unconscious eye movement directs our conscious behavior. In the most walkable districts, including new urbanist Chance Street and Vicksburg Square along Buena Vista Street, first fixations tended to be on building facades themselves. The research results from Chance Street suggest that one reason many residential areas are not walkable is that they do not provide requisite fixation points.
- Chance Street, with its emphasis on forward-looking, energy-conserving, compact community design, can establish a prototype for what 21st century development looks like as well as the means for new biometric assessment of its impact on the human brain and body.
- With the purpose of promoting walking rather than driving in communities, we should consider building neighborhoods with short block lengths and a sense of enclosure that consistently connects buildings, streets, and the pedestrian's point of view. Ideally, the front doors of buildings should not sit far away from the street, because this inadvertently blinds the pedestrian orientation needs.

Biometric tools, such as VAS, are useful in helping us better understand the human experience in new and existing communities. They can help us quickly grasp the difference between conventional, traditional, and new urbanist developments and see how the experience of each is framed in seconds. Biometric studies provide a new language, in which words like fixations and preattentive processing enter the urban planning lexicon to promote better place making and enable more accurate assessments of existing or planned communities. They aid in creating safe and healthy spaces, designed for people, acknowledging the hidden needs we all carry and appropriate ways of responding to them.

There is also the opportunity for further research to elaborate on these ideas. External stimuli contribute to our internal organization and subsequent behaviors; it is important to honor this. In other words, borrowing from Steve Jobs, the broader our understanding of the unconscious human experience, the better design we will have. Living in this new era of transformation from traditional to sustainable transportation planning, it is necessary for us to shift our attention to human reactions specific to particular functional zones, such as the residential area in this study. We must start to promote walkability by considering different groups' needs by learning about their unconscious experience.

Acknowledgments

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Notes

[I]We define conventional developments as postwar housing developments that are car-centric, prioritizing driver access over pedestrian access.

[II]Researchers also aimed for even lighting, with minimal shadows, and no people, trees, cars, or signs in the photos. However, for some photos, this proved to be an impossible task. Some buildings were located in popular areas that were always filled with people. Other buildings had trees planted or cars parked directly in front of them, and a number had shadows that were unavoidable.

[III]It is worth noting that Butterfly Lane in Lunenburg does not have sidewalks and that there could be a confounding factor here worthy of examination in future research.

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