

At-a-Glance: Exploring Glanceable Interfaces

ADAM SCHROFEL, University of Winnipeg, Canada

BRADLEY REY, University of Winnipeg, Canada

Glanceable visualizations, interfaces intended to be understood "at-a-glance", are increasingly appearing across Human Computer Interaction (HCI) literature on a variety of devices, yet the many terms for glanceable remain loosely defined (often not at all) within HCI. WE present a systematic literature review that categorizes how these terms are used, defined, and measured within HCI research. Using the term "glanc*" (* is a wildcard so any term beginning with "glanc") as a keyword, we retrieved 187 papers from ACM and IEEE libraries, then applied an iterative open-coding process to reach a final corpus of 68 papers. Each paper was coded along four dimensions: Definition, Technology, Data, Method. Our analysis reveals 71% of papers claim their interfaces/visualizations are glanceable, without any definition or reasoning as to why they have this characteristic. Additionally, we found existing temporal metrics for glances range anywhere from 200ms to 10s, with a 5s glance metric cited by only a small handful of studies. We outline an agenda for establishing empirically grounded, domain-sensitive metrics and analyze what characteristics and features of glanceable displays were frequently referenced. By mapping current practice and exposing gaps, this review lays the groundwork for more comparable studies and actionable design guidelines for future glanceable interfaces.

CCS Concepts: • **Do Not Use This Code** → **Generate the Correct Terms for Your Paper**; *Generate the Correct Terms for Your Paper*; Generate the Correct Terms for Your Paper; Generate the Correct Terms for Your Paper.

Additional Key Words and Phrases: Glanceable, Glanceability, Glance, Visualizations, Interfaces, Mobile Computing

ACM Reference Format:

Adam Schrofel and Bradley Rey. 2018. At-a-Glance: Exploring Glanceable Interfaces. In *Proceedings of Make sure to enter the correct conference title from your rights confirmation email (Conference acronym 'XX)*. ACM, New York, NY, USA, 11 pages. <https://doi.org/XXXXXXX.XXXXXXX>

1 Introduction

Glanceable displays, visualizations that can viewed at a glance, and the many terms that describe glanceability regarding interfaces is an increasingly mentioned concept within HCI thanks to the rise of mobile and wearable devices. Defining and characterizing what constitutes the quality of glanceable is a unenviable task given the complex nature of (NOT SURE). Many existing definitions and metrics are used to describe and assess the glanceability of a visualization, with different fields utilizing different thresholds, metrics, and definitions. This concept is increasingly important in contexts where users attention is limited (e.g. Mobile/Wearable Devices). However, despite frequent usage of terms like "glanceable" and "glanceability" in HCI, the literature frequently uses these terms without clearly defining or quantifying how an interface has these qualities, which has led to ambiguity and inconsistency in both research and application of these types of interfaces. This in turn has resulted in many studies using arbitrary temporal measurements for

Authors' Contact Information: Adam Schrofel, schrofel-a@webmail.uwinnipeg.ca, University of Winnipeg, MB, Winnipeg, Canada; Bradley Rey, b.rey@uwinnipeg.ca, University of Winnipeg, MB, Winnipeg, Canada.

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than the author(s) must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from permissions@acm.org.

© 2018 Copyright held by the owner/author(s). Publication rights licensed to ACM.

Manuscript submitted to ACM

Manuscript submitted to ACM

glances, without any verification of whether the durations truly measures the glanceability of an interface or the glance behaviour of the participants.

Related fields, specifically the Automotive Industry and Vision Science, use more rigorous definitions and metrics for glances. The automotive industry, driven by strict safety guidelines consistently employs a 3 tiered categorization of glances(short, medium, long), ranging between 0-2s, to measure interface glanceability and driver attention [2]. In contrast, Vision Science typically focuses on shorter metrics ranging between 50 to 500ms, which highlights their focus on rapid visual perception and recognition tasks. These fields have both successfully implemented standardized definitions, enabling concurrent evaluations of interfaces and user authentication, and clear comparisons between interfaces within their respective domains.

Looking outside these domains, the terms are still widely used but no consistency of definitions or metrics are employed. Motivated by this gap, our research aims to clarify and standardize the notion of glanceability within the HCI community. Establishing clear, consistent definitions and metrics is crucial for improving comparability among studies and developing meaningful design guidelines for glanceable interfaces/visualizations. With that in mind we also acknowledge the difficulty of defining a complex topic as many factors need to be accounted for when attempting to define such terms. We specifically investigate the following: How has glanceability/glanceable been defined across HCI literature? What measurable attributes (e.g. Temporal duration, information density, cognitive load) characterize a glanceable visualization? How consistently are these attributes measured and reported across existing research literature?

To address this, we conducted a literature review to investigate how the HCI community has implemented and defined glanceable visualizations and the many terms in line with that concept. We collected work that uses the term *glanc** (* is a wildcard so any term beginning with "glanc" was collected), and then applied an open coding process. We discuss how literature has defined glanceable and its other terms, and then reflect on the many issues and challenges presented by these existing definitions, or lack thereof. Discussions on the technology used to display these visuals, the domain of use the data being displayed is intended for, and Our approach included categorizing definitions, identifying commonly referenced metrics, and exploring the methodologies employed. By utilizing an iterative open coding process, we were able to refine a large group of HCI literature into a relevant and mature selection of final papers.

Our contribution a comprehensive literature review analyzing how the term glanceable and its many variations are used across HCI literature. We map out the existing definitions, highlight where inconsistencies arise in their usage, and propose considerations for future research. By clarifying the terms use across HCI literature, we aim to enable more comparable studies and better inform design guidelines for glanceable interfaces.

2 Related Work

While existing HCI literature on glanceable interfaces often remains fragmented and disconnected, adjacent fields and communities, specifically the Automotive Industry and Vision Science communities, have converged on clear and agreed upon metrics for glances. Examining their approaches sheds light on why HCI definitions may differ, and why such a gap between fields exists.

2.1 Automotive

The automotive industry has recognized the safety implications associated with visual attention demands imposed by in-vehicle interfaces, resulting in widely adopted metrics for glance durations. The U.S. Department of Transportation found that glances exceeding two seconds away from the road significantly increase near crash/crash risk [27]. This

two second metric has largely been recognized and is reflected in the National Highway Traffic Safety Administration (NHTSA) Driver Distraction Guidelines for In-Vehicle Electronic Devices [1]. The guidelines advise interface designs to limit visual demands to glances under this two second threshold. Building upon these guidelines, Bach et al. established a standardized methodology that categorizes eye glances into short (below 0.5 seconds), medium (between 0.5 - 2.0 seconds) and long (above 2.0 seconds) glances[2]. These metrics have been broadly applied across automotive studies to consistently evaluate driver attention and interface safety [13, 14, 19, 25]. Specifically, the 0.5 second threshold distinguishes brief, rapid eye movements from more deliberate fixations, which are indicative of focused attention [2]. By adhering to these thresholds, researchers can reliably compare interface designs and ensure that interactions within the vehicle remain within safe glance-duration limits.

2.2 Vision Science

The vision science community provides a foundation for understanding the limits of human perception relevant to glanceable interfaces. Blascheck et al. state the visual science community categorizes glances between 50 to 500 ms [4], which is derived from Holcombe's research on human perceptual limits which analyzes temporal thresholds ranging from 20 - 500ms.[22]. This notion of a glance lasting only a few hundred milliseconds is supported by Oliva's work on human perception using the term "*glance (about 200 ms)*"[33] and other Visual Science research []. This notion of glances being fast actions only a few hundred milliseconds long reflects a focus on rapid preattentive processing. Crucially the 500 millisecond cutoff marks the transition from preattentive to attentive processing, aligning conceptually with the 0.5s "short glance" threshold seen in automotive research. Vision Science metrics thus offer a physiological basis for designing interfaces that convey simplistic information within the brains earliest perceptual window.

Taken together, the automotive and vision science communities demonstrate how domain specific safety and perceptual requirements can drive consensus on glance durations. HCI's lack of a similarly unified metric or definitions creates challenges for comparing study results and guiding designs, we now look to show where these gaps emerge and how a standardized classification might bridge them.

3 Study

This section outlines our approach to investigate the usage of the many terminologies of glanceable visualizations within HCI literature. We conducted a qualitative analysis based on an open coding process, where a consensus based refinement process resulted in validating our code-book. Our goal was to establish a reproducible process, aligning with methods demonstrated in previous studies on visualizations[7].

Keyword Search: To build our corpus of papers, we performed a keyword search in the ACM Digital Library and IEEE Xplore for any paper published through January 2025 whose title, abstract, or author keywords contained the term "*glanc**" (* being a wildcard, resulting in any term beginning with "glanc" being collected). Within ACM we restricted sponsors to SIGCHI, SIGMM, and SIGMOBILE; in IEEE we restricted venues to TVCG, CGA, PacificVis, VRW, and VIS. This broad search yielded 187 initial papers, capturing a wide range of work that self identifies with glance-related technology.

3.1 Removals

The broad collection of initial papers led to us refine our code-book iteratively to select our final corpus of 68 papers.

Publication Type: First we excluded posters, short papers, workshops, videos, and proceedings to focus on mature, full-length studies. **Duplicates:** We then removed 19 duplicate papers gathered during initial paper collection. Looking to

determine relevancy we then moved towards removing papers that exclusively matched any of the following iteratively refined criteria:

- **Non-visualization:** We removed papers that only used the term "glanc*" in a non-visualization context(e.g. Person A glances at person B).
- **Author/Reader Action:** The author uses "glanc*" only to refer to their own action/process, or to direct the readers attention to a graphic or visual(e.g. "We direct the reader to glance at figure 4").
- **Name:** The term "glanc*" is only used as part of a name (e.g. Glancemug).
- **Third party:** Glanc* is being used only to describe something external to the paper itself.
- **Glance/Gaze Tracking:** Eye tracking being used to control an interface, or eye tracking being monitored but outside of the context of measuring glanceable/glanceability.

Through both rounds of removals we used the following procedure: We first discussed the possible exclusion criteria to develop initial codes. Then a subsection of papers was collected at random and each author separately coded the subsection. The assigned codes were then compared to determine if an 80% agreement was reached. Until that was met, we discussed refinement of codes and/or additional codes to be added to the code-book, then coded another subset of papers and compared again. When the threshold was met, the entire collection was independently coded, and any remaining disagreements were discussed and resolved. The final code-book was then created, comprising four dimensions—Definition, Data, Technology, and Method—providing a structured framework for our subsequent analysis.

4 Results

[illegible]

Fig. 1. Final corpus of papers with codes: Definition, Data, Technology, Method

Abbrev.	Code
NONE	No Definition
P 1	Pizza et al.
I 1	Isenberg
B 1	Blashchek et al. "Studies"
B 2	Blaschek et al. "Characterizing"
N 1	Neshati et al.
G 1	Gouveia et al. "Exploring"
G 2	Gouveia et al. "Habito"
M 1	Matthews et al.
OWN	Own Definition
O	Other
HW	Head-Worn Display
WA	Wearable Display (non-smartwatch)
TRAD	Traditional Display
SW	SmartWatch
SP	Smartphone
O	Other
T/E	Technology/Engineering
N/S	News/Social Media
CON	Consumer/Business
NASC	Natural Sciences
PERS	Personal
CIV	Civic
O	Other
CDW	Co-Design / Design Probe / Workshop / Focus Group
INT	One-on-One Interviews
PRO	Artifact/System Contribution/Prototype
LAB	Lab Study
FIEL	Field Study

Table 1. Abbreviations Used in Figure 1.

Our final code book categorizes 68 papers across the four previously mentioned dimensions (see Figure 1). These include *definition of glanc**, *technology*, *type of data*, and *method*, and spans publications from 2000-2025 across 18 venues: CHI, AVI, DIS, WSM, MM, IMMPD, ETRA, WPA, UBICOMP, ISS, UIST, SUI, CHIIR, PACIFIC VIS, TVCG, VR, VRW, CG&A. To analyze the trends across the literature, we outline key findings for each dimension.

4.1 Definitions of glanc*

The papers within the corpus can be categorized as papers that either define the concept of a "glanceable visual/interface", cite prior papers that defined a glanceable visualization, or do not contain a definition. A total of 48/68 papers do not contain any definition for glanc* or what constitutes a glanceable display or interface. The terms usage has notably seen a rise in recent years, with the exception of 2025, each year since 2014 contained 3 or more papers using the term. Prior to 2014, only a single year since 2000 contained 3 papers using the term (2003).

4.1.1 *No Definition.* The literature in this category often claims prototypes/visuals to be "glanceable" or carry glanceable characteristics. These works trend to treat glanceability as a self-evident property of their prototype or visualization, using the term descriptively but offering no operational criteria.

4.1.2 *Cited Definitions.* The only definitions of glanceable visualizations that are cited multiple times in the corpus are Matthews' definition [31], Gouveia et al.'s definition [16, 17], and Blascheck et al.'s definition [5, 6]. A total of 9/64 papers cite one of the three. Matthews work is not included in the final corpus as their thesis did not meet our selection criteria. Matthews defines glanceability as "*a visual quality that enables users to understand information quickly and with low cognitive effort.*" [31]. Gouveia et al.'s definition provides a metric for glances as "*brief, 5-second sessions where individuals check ongoing activity levels with no further interaction.*" [16, 17]. This 5 second metric is derived from the work of Banovic et al. where they define *glance sessions*, "*where the user only looks at the information on the locked screen or home screen of the phone*", where the median time spent with the lock screen open was 5 seconds [3]. The Gouveia et al. definition supports the notion of user attention and passive interactions, where a user is not interacting with the device housing the visualization and devoting minimal amounts of attention, similar to Matthews' definition. This 5 second threshold that Gouveia et al. defined is also referenced by Blascheck et al.'s definitions[5, 6].

4.1.3 *Own Definitions.* Other definitions include those that state the short temporal characteristic of a glanceable interface such as "*displays that can be apprehended with a minimum of attention*" [35] and "*easy to read and understand in a minimal amount of time*" [36]. Only one other paper that mentions a temporal metric as Healey et al. states "*Preattentive tasks can be performed in a single glance, which corresponds to 200 milliseconds (ms) or less.*" [21].

Other definitions include those that view glances as actions that do not require the users full attention [10], does not significantly disrupt ongoing activity [23], or without interaction [37]. This notion of attention, interaction, and ongoing primary tasks characterizing if displays were glanceable or visual attention was considered a glance is one we found relevant for further discussion.

4.2 Type of Technology

We coded the corpus based on the technology used within the paper that pertained to displaying glanceable visualizations. While traditional displays (38/68)—computers, monitors, televisions, and projectors—were still the dominant technology for visualizations, other technologies were still well represented (30/68), and Figure 1 reveals an increase in non-traditional technologies increasing usage within recent literature. Trends of note include the shift away from mobile devices to smartwatch visualizations (10/68), as well as the increase in head-worn displays(10/68)(e.g. AR) in recent literature. Notably, papers working with smartwatch visualizations acknowledged the challenges of creating glanceable visuals for the smaller smartwatch displays [23][17][38][26]. One group designed wearable displays(non-smartwatch) such as screens on the backs of runners shirts to visualize real-time run tracking information in a group setting [32], and printable chemical patches that mediate the users relationship with their surrounding environment(e.g. Current UV exposure)[30].

4.3 Type of Data

The data being displayed within the papers of the corpus were quite varied and spanned across multiple domains. The most frequent data group belonged to *Technology/Engineering* (21/68) which included included Network Traffic [15], and Graph comparisons [40]. Another group frequently displayed was *Personal Data* (18/68) including Personal Health data[32][20][16][17][24] . We categorized *Civic data* as any public data in a group setting, this included city mapping

[9], and city district water heating data[12]. Another group included *Natural Sciences*, containing a variety of data such as maps for molecular surfaces [28], and hierarchically scaled visualizations of DNA [18]. *Other*(11/68) included a variety of data such as classroom data [29], and tennis match data [34].

4.4 Type of Method

The vast majority of papers involved a *Artifact/System Contribution/Prototype* (60/68). Unsurprisingly the use of Lab studies (42/68) and/or Field Studies (22/68) were widely utilized throughout as well. Other groups included *One-on-One Interviews* (18/68), *Co-Design / Design Probe / Workshop / Focus Group* (8/68), and *Other* (6/68), which included online questionnaires [30][29].

5 Discussion

Although glanceability and its many terms has become a commonplace concept within HCI literature, our review reveals a lack of any agreed upon definition or metric. 71% of papers provide definition, with no regard for whether the interface of visualization has any characteristic that would entail that interface or visualization actually having a "glanceable" quality. Of the papers that do offer their own or cited definition, there is little consensus to be had, besides the use of the 5 second metric within a small circle of work[5, 6, 8, 16, 17, 26]. The usage of this metric is a step towards consistency across the field, the metric itself is slightly problematic in that it is derived from a study not necessarily concerned with the notion of glanceability, rather interaction times with devices, with no regard for whether a user is intentionally glancing at the device and inferring information of some kind [3]. Overall, this lack of consensus reflects glanceability's inherently complex nature, which spans multiple disciplines, interaction contexts, and users.

Beyond this, the literature that does provide definitions for glanceable can be pooled into two broad, slightly overlapping schools of thought. One views glanceable displays as peripheral reference points, secondary and supplementary information that does not interrupt a primary task (e.g. [11, 23]). The other treats it more as a direct visual attention but for a limited period, where users briefly focus their full attention on the display. These two trains of thought converge in that these glanceable displays are brief, simple to view, and put minimal strain on the users cognitive functioning. With that in mind, we further refine existing literature of glanceable displays into these following key characteristics. **Cognitive Load:** Glances should impose minimal effort, as not to disrupt ongoing primary tasks or exceed users attention limits. **Temporal Window:** Glances must have some sort of temporal metric associated with them. Current literature ranging from 200 milliseconds to 10 seconds is far too broad and needs refinement. **Information Density:** Visualizations must be abstracted or simplified to be understood with a glance.

To offer a concrete definition would be foolish given the complex nature of glanceability, with so many factors to consider, including: user characteristics and experience with said interfaces, domain of usage, and field of study. For example, Age is a consideration that 2 papers within the corpus take into account and attempt to address the challenges of designing glanceable displays for older users (citing the cognitive challenges older users face compared to younger, and the limited amount of information able to be ingested within the same time frame.)[39][8]. Again, this is in part due to the challenging nature of defining what such a term could mean, as discussed extensively by Blascheck et al. in their textbook chapter on Glanceability[4]. They breaks down the metrics and characteristics of glanceable displays into three distinct fields with their own metrics, Vision Science(0 - 500 ms), Visualization (0.5s - 2s) and Ubiquitous computing(2s-10+s). As well, Blascheck et al. synthesize prior definitions from across domains (Vision Science, Visualization, and Ubiquitous Computing) to propose characteristics of glanceable displays[4]. They are *present & accessible*, Designed with *simplicity & understanding* in mind, and the importance of reflecting on the *suitability &*

purpose of a glanceable visualization for a given goal of the user. However, Matthews offers the following: *"Glanceability is not an evaluation criteria, but it is a design mechanism through which designers can improve a display's learnability, improve user awareness, minimize distraction caused by time taken to interpret a display, and increase appeal."*[31]. Having a definition that sufficiently encapsulates this, and many other considerations for glanceable displays is unlikely, and likely a reason why there is such a lack of an agreed upon definition within HCI. Given the rapid increase in mobile in-situ displays and overall mobile device usage, we argue that an agreed-upon temporal metric is both necessary and achievable. Safety considerations need to be taken into account, and like the automotive industry, there must be some temporal metric that can be agreed upon and broadly used throughout future HCI research. The 5 second metric is a step in the right direction, but studies pertaining directly to user glances with regards to safe mobile device usage is needed. Future glanceability research could also adopt baseline thresholds, like the 5 second metric, and refine them according to user characteristics, context of use, and other factors. Overall an agreed upon temporal metric would provide a shared operational criteria that is desperately needed to compare and synthesize glanceable interface studies, while considerations for glanceable characteristics would still accommodate the term's inherent complexity.

6 Conclusion

Our literature review makes clear that, despite the consistent usage of glanceable and its many terms, HCI lacks a shared consistent usage of definitions and temporal metrics. Nearly three-quarters of the 68 papers in our final corpus describe interfaces as glanceable while offering criteria that the interfaces meet for that claim to have validity. Those that do define the concept disagree in key areas at times, most visibly regarding temporal metrics that stretch from sub-second perceptual thresholds to interaction windows upwards of 10 seconds. We also observed a shift toward non-traditional displays (e.g. smartwatches and head-worn displays) and a growing diversity of data domains. Drawing on patterns across the corpus, we argue that future work should make considerations to the following :

- **Temporal metric:** An evidence-based metric for safe, task-compatible glances. We argue that further research is required to establish an agreed upon metric, rather than inferring one from studies unrelated to the context of glanceability. Until that point, using the 5s metric and refining it based on context, users, and other considerations.
- **Design Considerations:** Considerations towards existing characteristics present within HCI literature such as **Cognitive Load** (Minimal attention cost relative to the users primary activity), **Information Density** (an abstraction level that affords quick and simple comprehension), and other proposed characteristics such as those presented by Blascheck et al. [4] will enable future work to maintain a close alignment with existing sentiment towards features of glanceable displays.

This paper aspires to shift discourse from implied understanding and acceptance, back to working towards standardizing and accepting metrics for glanceable displays. This will ultimately support safer, more effective interfaces for the rapidly expanding ecosystem of on-the-go technologies.

Acknowledgments

I would like to thank my parents for supporting me throughout my educational journey. Without them and their unwavering support through many struggles I would not have been able to reach this point. I would also like to thank Dr. Rey for motivating and supporting me throughout this process. His constant encouragement through a difficult period in my life and his constant passion for his work provided the motivation I needed to complete this.

References

- [1] 2013. Visual-Manual NHTSA Driver Distraction Guidelines for In-Vehicle Electronic Devices.
- [2] Kenneth Majlund Bach, Mads Gregers Jæger, Mikael B. Skov, and Nils Gram Thomassen. 2008. You can touch, but you can't look: interacting with in-vehicle systems. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Florence, Italy) (*CHI '08*). Association for Computing Machinery, New York, NY, USA, 1139–1148. doi:10.1145/1357054.1357233
- [3] Nikola Banovic, Christina Brant, Jennifer Mankoff, and Anind Dey. 2014. ProactiveTasks: the short of mobile device use sessions. In *Proceedings of the 16th International Conference on Human-Computer Interaction with Mobile Devices & Services* (Toronto, ON, Canada) (*MobileHCI '14*). Association for Computing Machinery, New York, NY, USA, 243–252. doi:10.1145/2628363.2628380
- [4] Tanja Blascheck, Frank Bentley, Eun Kyoung Choe, Tom Horak, and Petra Isenberg. 2021. Characterizing Glanceable Visualizations: From Perception to Behavior Change. In *Mobile Data Visualization*. Chapman and Hall/CRC, Chapter 5, 151–176. doi:10.1201/9781003090823-5
- [5] Tanja Blascheck, Lonni Besançon, Anastasia Bezerianos, Bongshin Lee, and Petra Isenberg. 2019. Glanceable Visualization: Studies of Data Comparison Performance on Smartwatches. *IEEE Transactions on Visualization and Computer Graphics* 25, 1 (Jan. 2019), 630–640. doi:10.1109/TVCG.2018.2865142
- [6] Tanja Blascheck, Lonni Besançon, Anastasia Bezerianos, Bongshin Lee, Alaul Islam, Tingying He, and Petra Isenberg. 2023. Studies of Part-to-Whole Glanceable Visualizations on Smartwatch Faces. In *2023 IEEE 16th Pacific Visualization Symposium (PacificVis)*. 187–196. doi:10.1109/PacificVis56936.2023.00028
- [7] Nathalie Bressa, Henrik Korsgaard, Aurélien Tabard, Steven Houben, and Jo Vermeulen. 2022. What's the Situation with Situated Visualization? A Survey and Perspectives on Situatedness. *IEEE Transactions on Visualization and Computer Graphics* 28, 1 (Jan 2022), 107–117. doi:10.1109/TVCG.2021.3114835
- [8] Gabriela Cajamarca, Valeria Herskovic, Stephannie Dondighual, Carolina Fuentes, and Nervo Verdezoto. 2023. Understanding how to Design Health Data Visualizations for Chilean Older Adults on Mobile Devices. In *Proceedings of the 2023 ACM Designing Interactive Systems Conference* (Pittsburgh, PA, USA) (*DIS '23*). Association for Computing Machinery, New York, NY, USA, 1309–1324. doi:10.1145/3563657.3596109
- [9] Remco Chang, Ginette Wessel, Robert Kosara, Eric Sauda, and William Ribarsky. 2007. Legible Cities: Focus-Dependent Multi-Resolution Visualization of Urban Relationships. *IEEE Transactions on Visualization and Computer Graphics* 13, 6 (Nov 2007), 1169–1175. doi:10.1109/TVCG.2007.70574
- [10] Pei-Yu Chi, Bongshin Lee, and Steven M. Drucker. 2014. DemoWiz: re-performing software demonstrations for a live presentation. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Toronto, Ontario, Canada) (*CHI '14*). Association for Computing Machinery, New York, NY, USA, 1581–1590. doi:10.1145/2556288.2557254
- [11] Shakiba Davari, Feiyu Lu, and Doug A. Bowman. 2020. Occlusion Management Techniques for Everyday Glanceable AR Interfaces. In *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*. 324–330. doi:10.1109/VRW50115.2020.00072
- [12] Veronika Domova, Alvaro Aranda Muñoz, Elsa Vaara, and Petra Edoff. 2019. Feel the Water: Expressing Physicality of District Heating Processes in Functional Overview Displays. In *Proceedings of the 2019 ACM International Conference on Interactive Surfaces and Spaces* (Daejeon, Republic of Korea) (*ISS '19*). Association for Computing Machinery, New York, NY, USA, 229–240. doi:10.1145/3343055.3359708
- [13] Patrick Ebel, Moritz Berger, Christoph Lingenfelder, and Andreas Vogelsang. 2022. How Do Drivers Self-Regulate their Secondary Task Engagements? The Effect of Driving Automation on Touchscreen Interactions and Glance Behavior. In *Proceedings of the 14th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (Seoul, Republic of Korea) (*AutomotiveUI '22*). Association for Computing Machinery, New York, NY, USA, 263–273. doi:10.1145/3543174.3545173
- [14] Peter Fröhlich, Matthias Baldauf, Stefan Suetter, Dietmar Schabus, and Matthias Fuchs. 2012. Investigating in-car safety services on the motorway: the role of screen size. In *CHI '12 Extended Abstracts on Human Factors in Computing Systems* (Austin, Texas, USA) (*CHI EA '12*). Association for Computing Machinery, New York, NY, USA, 1787–1792. doi:10.1145/2212776.2223710
- [15] John R. Goodall, A. Ant Ozok, Wayne G. Lutters, Penny Rheingans, and Anita Komlodi. 2005. A user-centered approach to visualizing network traffic for intrusion detection. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems* (Portland, OR, USA) (*CHI EA '05*). Association for Computing Machinery, New York, NY, USA, 1403–1406. doi:10.1145/1056808.1056927
- [16] Rúben Gouveia, Evangelos Karapanos, and Marc Hassenzahl. 2015. How do we engage with activity trackers? a longitudinal study of Habito. In *Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (Osaka, Japan) (*UbiComp '15*). Association for Computing Machinery, New York, NY, USA, 1305–1316. doi:10.1145/2750858.2804290
- [17] Rúben Gouveia, Fábio Pereira, Evangelos Karapanos, Sean A. Munson, and Marc Hassenzahl. 2016. Exploring the design space of glanceable feedback for physical activity trackers. In *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (Heidelberg, Germany) (*UbiComp '16*). Association for Computing Machinery, New York, NY, USA, 144–155. doi:10.1145/2971648.2971754
- [18] Sarkis Halladjian, David Kouril, Haichao Miao, M. Eduard Gröller, Ivan Viola, and Tobias Isenberg. 2022. Multiscale Unfolding: Illustratively Visualizing the Whole Genome at a Glance. *IEEE Transactions on Visualization and Computer Graphics* 28, 10 (Oct 2022), 3456–3470. doi:10.1109/TVCG.2021.3065443
- [19] Kyle Harrington, David R. Large, Gary Burnett, and Orestis Georgiou. 2018. Exploring the Use of Mid-Air Ultrasonic Feedback to Enhance Automotive User Interfaces. In *Proceedings of the 10th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (Toronto, ON, Canada) (*AutomotiveUI '18*). Association for Computing Machinery, New York, NY, USA, 11–20. doi:10.1145/3239060.3239089

- [20] Qian He and Emmanuel Agu. 2014. On11: an activity recommendation application to mitigate sedentary lifestyle. In *Proceedings of the 2014 Workshop on Physical Analytics* (Bretton Woods, New Hampshire, USA) (WPA '14). Association for Computing Machinery, New York, NY, USA, 3–8. doi:10.1145/2611264.2611268
- [21] Christopher G. Healey and James T. Enns. 1999. Large Datasets at a Glance: Combining Textures and Colors in Scientific Visualization. *IEEE Transactions on Visualization and Computer Graphics* 5, 2 (April 1999), 145–167. doi:10.1109/2945.773807
- [22] Alex O Holcombe. 2009. Seeing slow and seeing fast: two limits on perception. *Trends in cognitive sciences* 13, 5 (2009), 216–221. doi:10.1016/j.tics.2009.02.005
- [23] Stephen Intille, Caitlin Haynes, Dharam Maniar, Aditya Ponnada, and Justin Manjourides. 2016. EMA: Microinteraction-based ecological momentary assessment (EMA) using a smartwatch. In *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing* (Heidelberg, Germany) (UbiComp '16). Association for Computing Machinery, New York, NY, USA, 1124–1128. doi:10.1145/2971648.2971717
- [24] Alaul Islam, Ranjini Aravind, Tanja Blascheck, Anastasia Bezerianos, and Petra Isenberg. 2022. Preferences and Effectiveness of Sleep Data Visualizations for Smartwatches and Fitness Bands. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) (CHI '22). Association for Computing Machinery, New York, NY, USA, Article 27, 17 pages. doi:10.1145/3491102.3501921
- [25] Brit Susan Jensen, Mikael B. Skov, and Nissanthan Thiruravichandran. 2010. Studying driver attention and behaviour for three configurations of GPS navigation in real traffic driving. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Atlanta, Georgia, USA) (CHI '10). Association for Computing Machinery, New York, NY, USA, 1271–1280. doi:10.1145/1753326.1753517
- [26] Konstantin Klamka, Tom Horak, and Raimund Dachselt. 2020. Watch+Strap: Extending Smartwatches with Interactive StrapDisplays. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) (CHI '20). Association for Computing Machinery, New York, NY, USA, 1–15. doi:10.1145/3313831.3376199
- [27] T A;Neale V L;Sudweeks J D;Ramsey D J; Klauer, S. G.;Dingus. [n. d.]. The Impact of Driver Inattention on Near-Crash/Crash Risk: An Analysis Using the 100-Car Naturalistic Driving Study Data.
- [28] Michael Krone, Florian Frieß, Katrin Scharnowski, Guido Reina, Silvia Fademrecht, Tobias Kulschewski, Jürgen Pleiss, and Thomas Ertl. 2017. Molecular Surface Maps. *IEEE Transactions on Visualization and Computer Graphics* 23, 1 (Jan 2017), 701–710. doi:10.1109/TVCG.2016.2598824
- [29] Shuai Ma, Taichang Zhou, Fei Nie, and Xiaojuan Ma. 2022. Glancee: An Adaptable System for Instructors to Grasp Student Learning Status in Synchronous Online Classes. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems* (New Orleans, LA, USA) (CHI '22). Association for Computing Machinery, New York, NY, USA, Article 313, 25 pages. doi:10.1145/3491102.3517482
- [30] Alex Mariakakis, Sifang Chen, Bichlien H. Nguyen, Kirsten Bray, Molly Blank, Jonathan Lester, Lauren Ryan, Paul Johns, Gonzalo Ramos, and Asta Roseway. 2020. EcoPatches: Maker-Friendly Chemical-Based UV Sensing. In *Proceedings of the 2020 ACM Designing Interactive Systems Conference* (Eindhoven, Netherlands) (DIS '20). Association for Computing Machinery, New York, NY, USA, 1983–1994. doi:10.1145/3357236.3395424
- [31] Tara Lynn Matthews. 2007. *Designing and evaluating glanceable peripheral displays*. Ph. D. Dissertation. USA. Advisor(s) Mankoff, Jennifer and Canny, John. AAI3275515.
- [32] Matthew Mauriello, Michael Gubbels, and Jon E. Froehlich. 2014. Social fabric fitness: the design and evaluation of wearable E-textile displays to support group running. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Toronto, Ontario, Canada) (CHI '14). Association for Computing Machinery, New York, NY, USA, 2833–2842. doi:10.1145/2556288.2557299
- [33] Aude Oliva. 2005. CHAPTER 41 - Gist of the Scene. In *Neurobiology of Attention*, Laurent Itti, Geraint Rees, and John K. Tsotsos (Eds.). Academic Press, Burlington, 251–256. doi:10.1016/B978-012375731-9/50045-8
- [34] Tom Polk, Dominik Jäckle, Johannes Häußler, and Jing Yang. 2020. CourtTime: Generating Actionable Insights into Tennis Matches Using Visual Analytics. *IEEE Transactions on Visualization and Computer Graphics* 26, 1 (Jan 2020), 397–406. doi:10.1109/TVCG.2019.2934243
- [35] Daniel C. Robbins, Bongshin Lee, and Roland Fernandez. 2008. TapGlance: designing a unified smartphone interface. In *Proceedings of the 7th ACM Conference on Designing Interactive Systems* (Cape Town, South Africa) (DIS '08). Association for Computing Machinery, New York, NY, USA, 386–394. doi:10.1145/1394445.1394487
- [36] Maarten van Dantzich, Daniel Robbins, Eric Horvitz, and Mary Czerwinski. 2002. Scope: providing awareness of multiple notifications at a glance. In *Proceedings of the Working Conference on Advanced Visual Interfaces* (Trento, Italy) (AVI '02). Association for Computing Machinery, New York, NY, USA, 267–281. doi:10.1145/1556262.1556306
- [37] Gina Danielle Venolia and Carman Neustaedter. 2003. Understanding sequence and reply relationships within email conversations: a mixed-model visualization. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (Ft. Lauderdale, Florida, USA) (CHI '03). Association for Computing Machinery, New York, NY, USA, 361–368. doi:10.1145/642611.642674
- [38] Dirk Wenig, Johannes Schöning, Alex Olwal, Mathias Oben, and Rainer Malaka. 2017. WatchThru: Expanding Smartwatch Displays with Mid-air Visuals and Wrist-worn Augmented Reality. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems* (Denver, Colorado, USA) (CHI '17). Association for Computing Machinery, New York, NY, USA, 716–721. doi:10.1145/3025453.3025852
- [39] Zack While, Tanja Blascheck, Yujie Gong, Petra Isenberg, and Ali Sarvghad. 2024. Glanceable Data Visualizations for Older Adults: Establishing Thresholds and Examining Disparities Between Age Groups. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (Honolulu, HI, USA) (CHI '24). Association for Computing Machinery, New York, NY, USA, Article 987, 17 pages. doi:10.1145/3613904.3642776
- [40] Vahan Yeghoushian, Tim Dwyer, Karsten Klein, Kim Marriott, and Michael Wybrow. 2018. Graph Thumbnails: Identifying and Comparing Multiple Graphs at a Glance. *IEEE Transactions on Visualization and Computer Graphics* 24, 12 (Dec 2018), 3081–3095. doi:10.1109/TVCG.2018.2790961