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Characterizing the current state of mobile thematic cartography

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Abstract:

Mobile devices such as tablets, smartphones, and smartwatches have rapidly become part of everyday life. These devices give users access to many types of mobile maps, such as navigation maps, weather maps, maps in the news, map-based games, and citizen science projects. Currently, most research in mobile cartography is focused on reference and navigation maps. However, following recent calls to action on more expansive mobile map research (Roth et al., 2024), I have recently conducted research on mobile *thematic* maps, specifically in the context of data journalism (Houtman, 2024).

Here, I present a literature review that extends my previous work on mobile thematic maps in two ways. First, I consider mobile thematic maps on tablets and smartwatches, in addition to smartphones. Second, I consider mobile thematic maps more expansively, rather than solely for data journalism. In this review, I characterize five themes that inform the design and development of mobile thematic maps: audience, device variation, location of operation, screen space and interactions, and diverse accessibility.

Audience: Audience is a key consideration in all forms of cartography, both for web and print cartography. Audience is one of the three parts of MacEachren's Cartography Cube, for example, which assists cartographers in determining where their map might lie on a scale from visualization to communication (MacEachren, 1994). However, considering the type of audience may be even more important for mobile devices than desktop devices. Compared to paper maps and desktop devices, mobile devices have more notifications and alerts, resulting in more distractions. Additionally, users are more likely to access mobile devices in unstable conditions, such as while walking. Reports from data journalists suggest that general audiences are very unlikely to interact with a news map (Houtman, 2024). Meanwhile, experts who use a mobile thematic map, such as farmers using an agriculture app or scientists utilizing a specially designed tool, will typically expect more specialized interactive features and face fewer distracting notifications.

Device Variation: When a map is designed for a mobile device, whether as an app or within a browser, the developer must consider which devices it will be accessed on. Typically, browser-based maps are expected to be responsive and work seamlessly across phones, tablets, and computers. Meanwhile, apps may be more limited, and may only be developed for one type of device. If the map is developed for multiple devices, some developers may design it as mobile-first or desktop-first, based on where the majority of users are expected to be. However, cartographers may also practice simultaneous design, where they design for multiple screen sizes at once instead of prioritizing a particular screen size (Hoffswell et al., 2020). However, even mobile thematic maps which are developed for only one screen type still must include some level of adaptation, since phones vary in their overall area and in their length to width ratio (Abraham, 2019).

Location of Operation: Mobile devices are inherently designed to be brought to many locations and used while moving, so mobile thematic maps must be designed with consideration for where the map might be used. Certain scientific maps, such as geologic maps, might be expected to be brought into field sites away from fast internet connections and viewed under bright sunlight. Weather maps and breaking news maps might be read quickly while the user is walking. Some maps may have multiple audiences; a disaster map of a current wildfire in Africa might be used by local individuals attempting to flee *and* by concerned family members on another continent. Given the varied scenarios that mobile thematic maps may be viewed in, cartographers must consider the limitations for their product. Maps viewed outdoors may need higher contrast (Loeffler et al., 2021). Maps viewed in locations with limited data access, such as areas far from cities or underground on the subway, may need to be simplified to load easily (Coltekin & Reichenbacher, 2011). Additionally, mobile thematic maps should not make heavy data requests that drain device batteries or that do not function well for individuals with older devices.

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Screen Space and Interactions: The major types of mobile devices - tablet, smartphone, and smartwatch - have some variations in their orientation, size, and potential interactions. To maximize accessibility, mobile thematic maps should be designed for the device with the most constraints on interaction and size. Tablets are the largest of the three device types and are comfortably used in either portrait or landscape orientation, though they are somewhat square. Phones are typically much less square than tablets and rarely used in a landscape orientation. They are smaller than tablets, however there is great variation in their overall size. Smartwatches are by far the smallest of all, and relatively square. Tablets and phones allow similar interactions. The most common interaction is a single finger to tap or pinch, although multi-finger interactions and long-press interactions are also possible. Some tablets allow a physical keyboard to be connected, allowing similar functionality as a laptop. Smartwatches also allow tap input. Additionally, there may be additional interactions, such as the use of the side wheel to scroll or the side button to dismiss. By enabling accessibility features, some smartwatches allow the user to make a fist or pinch their fingers on the hand connected to the watch, serving the same function as a "tap" in a way that is accessible to users with only one arm. These interactions are different from the ones available on desktop devices, warranting research into their utility for mobile thematic maps.

Diverse Accessibility: Accessibility for individuals with diverse abilities, such as limb differences or visual impairments, is important for maps on all devices. However, many developments in accessibility are primarily designed for desktop devices, such as screen readers, with limited functionality on mobile devices. Additionally, within cartography and data visualization, most accessibility guidelines focus on colour-blindness, followed by developments for blind or low vision users. Wimer and colleagues (2024) point out that other differences in ability, such as limb differences, cognitive differences, and motor differences are rarely considered in the data visualization literature. Limitations related to limbs and motor abilities are particularly important when designing thematic maps for mobile devices, given their limited screen size and the fact that mobile devices are typically handheld. Alternative forms of input, such as voice commands or hand gestures on smartwatches offer possible solutions. Similarly, cartographers who develop for mobile must ensure tappable icons meet or exceed minimum size standards (Ledermann, 2023).

This literature review serves as a preliminary understanding of the state of mobile thematic cartography, including current limitations and opportunities. This review considers mobile thematic maps for any subject or purpose and is inclusive of smartwatch, smartphone, and tablet devices. Following this review, I intend to expand current knowledge about mobile thematic maps through expert needs assessments, focus groups, and usability studies. In conducting this research, I hope to excite other scholars about mobile thematic maps and increase the number of research studies on this subject in the future.

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