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Situating Trust in Cartography: Why do People Trust Maps and What does Trust in Maps Mean?

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A longstanding assertion among cartographers is that people place a great deal of trust in maps. Despite this claim and the growing importance of understanding trust in a post-truth society, research on trust in cartography is scarce. It remains unclear why, how, and if maps are inherently trustworthy. Moreover, the existing research on trust in maps fails to define trust, or uses inconsistent definitions that muddy whether trust is actually being studied or not. This paper sets out to situate trust in cartography by examining the arguments as to why people may trust maps more than other kinds of information and by exploring how trust has been defined. I propose five reasons as to why maps may be inherently trustworthy, owing to their authoritative, objective, realistic, ubiquitous, and useful nature. I buttress each of these reasons with psychological theory and I discuss variable-specific characteristics of maps that may affect trust. Additionally, I generate a theoretical definition of trust in maps by extracting key components from existing definitions and conceptualizations. This definition emphasizes that trust in maps revolves around relying on the visual geospatial information interpreted from a map and on believing the map is accurate.

KEYWORDS: trust; cartographic design; persuasion; misinformation; psychology

INTRODUCTION

Mapmaking is a complex process, involving a string of design choices that always result in some sort of simplification and bias. People who have some cartographic education are trained to follow cartographic best practices to minimize the potential for maps to be misleading, but even they can make mistakes and create misleading maps. Moreover, maps enjoy a long history of use as rhetorical devices that push a particular narrative and serve narrow interests (Tyner 1982). Maps are effective propaganda tools because they seem neutral and convey information in an intuitive way. These traits, among others, are believed to make maps especially trustworthy forms of communication. This trustworthiness is potentially dangerous in the modern media landscape as misleading maps are more abundant and can easily become viral if people place high degrees of trust in them, thereby amplifying their negative impact.

Cartographers have made several arguments that maps are inherently trustworthy (Bar-Gal 2003; Boggs 1947; Churchill and Slarsky 2004; Francaviglia 1995), but little empirical evidence exists to back these arguments up. To make these arguments testable and robust, it is necessary to identify specific mechanisms driving the psychological tendency to trust maps. Thus, one of the two major goals of this paper is to tease out specific traits of maps that may prompt people to trust them more.

While *trustworthiness* constitutes a property of something, and is tied up with perceived credibility, *trust* refers to a psychological state of vulnerability where an individual relies on someone/something based on positive expectations of their/its behavior (McKnight and Chervany 2001; Sundar and Venkatesakumar 2013). Considerable work has been dedicated to conceptualizing and studying interpersonal (Ganesan and Hess 1997) and institutional (Cole and Cohn 2016) trust, but it remains unclear if these conceptualizations and definitions extend to the context of maps. Conceptualizations of media *trust* and *credibility* (terms used interchangeably in media studies)

offer stronger parallels to trust in maps, as they are concerned with whether people trust the information that they consume (Fisher 2018). Specifically, *message credibility* describes "an individual's judgment of the veracity of the content of communication" (Appelman and Sundar 2016, 63). I argue that message credibility is suitable to inform the conceptualization of trust in maps, as maps are a type of communication that visualizes spatial content.

While trust has been defined in numerous other disciplines, and some preliminary definitions exist in cartography, these definitions do not tap into what is unique about trust in maps, nor do they carefully consider the fundamental pieces that make up trust in maps. Thus, the second goal of this paper is to explore what is unique about trusting maps and distill the concept into its core characteristics. Explicating trust in maps will resolve these limitations of prior works while working towards a more robust definition. I accomplish the two major goals of this paper—investigating traits of maps that promote trustworthiness and defining trust—by reviewing existing research on trust in maps and connecting such research to theory in (communication) psychology.

Since the outcome of the second goal helps orient a reader to the rest of the paper, I will provide here the definition of trust in maps that I arrived at: *the willingness to rely on the map contents based on the expectation that the representation of geographic phenomena is accurate and unbiased*. I document how I arrived at this definition and argue that trust is unique when maps are the *trustee* (the entity in which trust is placed) in the rest of the paper. Since defining *map* is a whole research paper in itself, I adopt the following definition to scope this paper: an authored spatial representation of reality (Griffin 2021; International Cartographic Association 2003). Such a definition includes thematic maps, reference maps, and satellite maps.

The rest of the paper is organized as follows. First, I synthesize different hypotheses as to why maps may be perceived as an especially trustworthy type of information communication. I attempt to augment these hypotheses by grounding them in psychological theory and identify specific traits of maps that may make people trust them more. In doing so, I make a case for what is unique about trust when the trustee is a map. Second, I survey different conceptualizations and definitions of trust in cartographic literature to tease out its core elements. These core elements are fused together in order to construct a robust definition of trust in maps. Finally, I conclude by summarizing key contributions, disclosing limitations of my work, and charting future work.

TRUSTWORTHY TRAITS OF MAPS

In this section I explore the traits of maps that foster trustworthiness. I begin by introducing multiple theoretical frameworks that can help explain why people may trust maps. I then synthesize the arguments of cartographic scholars as to why people are predisposed to (overly) trust maps. For each of these arguments, I identify theoretical reasons backing them up. Finally, specific characteristics of maps that may affect trust judgments are identified and discussed.

THEORETICAL FRAMEWORKS

The MAIN Model

This work will largely draw on the MAIN model (Sundar 2008) to provide theoretical backing to the claims made by cartographic scholars. The MAIN model posits that media have four major classes of technological affordances (i.e., modality, agency, interactivity, and navigability) that can cue cognitive heuristics that in turn affect credibility assessments. Cognitive heuristics are mental shortcuts that enable people to make quick decisions, which, in the case of the MAIN model, are about credibility judgments (Sundar 2008). A major assumption of the MAIN model is that digital media users predominantly base credibility judgements on peripheral cues that do not require intensive cognitive effort, since the current media consumption environment overloads users with information (Metzger 2007; Sundar 2008). These cues trigger cognitive heuristics that reduce cognitive effort, so users are not cognitively overloaded when browsing media (Lang 2000).

One major class of heuristics, *modality*, derives from visual cues afforded by the form of communication (i.e., text, image, and video). Modality cues and heuristics are of particular relevance to maps, as maps are a hybrid modality that primarily use non-verbal visuals but also use verbal text to convey information. When maps are coupled with

modern technology, they can trigger cognitive heuristics. For instance, a map viewed on an augmented reality headset cues the *being-there* heuristic since the multimedia is immersive and allows a user to feel as if they are in the map. Consequently, users will trust the map more, as it feels authentic and immersive.

Agency affordances will also be investigated in this paper, as maps have a long history of being made by trustworthy institutions, but in the recent past maps have been increasingly made by entities of unknown trustworthiness. Nonprofessionals can more easily make polished-looking maps that may evoke the authority that maps have historically carried. Further, maps are now often disseminated on social media where collaborative assessments of maps can affect their apparent credibility (Robinson 2019). For example, if a map has a high number of likes and positive comments from other users, this will likely cue the *bandwagon heuristic* and make people trust the content more, since it is endorsed by many other users. The idea of agency revolves around the source of communication and whether users feel as if (1) they are the source, (2) others are the source, or (3) the source is a competent expert (Sundar 2008).

While the MAIN model centers on *credibility*, I argue that it is suitable to also apply it in the context of *trust* and maps. The terms trust and credibility represent related but distinct concepts. Credibility is synonymous with believability whereas trust is synonymous with dependability (Fogg and Tseng 1999). Credibility is often defined as an individual's perception of the believability and truthfulness of information, and researchers measure it in terms of attractiveness, expertise, and trustworthiness (Metzger et al. 2003). While credibility can be thought of as an assessment of information, trust is a mental state in which an individual is willing to rely on information with an expectation that reliance will lead to a desirable outcome (Kelton et al. 2008). Trust also has three dimensions: emotional, cognitive, and behavioral (Lewis and Weigert 1985).

Despite the differences between the two concepts, they are closely related to each other, and they are used interchangeably in media studies (Fisher 2018) and information visualization literature (Kong et al. 2019; Elhamdadi et al. 2022). Researchers view credibility as an antecedent to trust and vice versa (Van Dalen 2020). In addition, the two variables demonstrate strong associations with one another (Soh et al. 2009). Provided that, this paper assumes that the MAIN model is appropriate as a theoretical framework to explore trust in maps.

The Heuristic-Systematic Model of Persuasion

In addition to the MAIN model, this paper will draw on the Heuristic-Systematic Processing Model (HSM). According to HSM, individuals can process information systematically and/or heuristically (Eagly and Chaiken 1993). Systematic information processing requires high cognitive effort as individuals scrutinize with great detail the message that is provided to them. On the flip side, heuristic processing involves the assessment of messages based on cognitive heuristics (simple decision rules) formed through lived experiences. Put another way, someone reading a map made by the US Census Bureau via systematic processing will thoughtfully and carefully consider the visualization—from who made it, where they got the data, how legible it is, which colors were used, etc. Someone reading the same map via heuristic processing will make a quick judgment about the map by using a mental shortcut such as "experts are reliable" and trust the map because it was made by the US Census Bureau, a reputable government organization. The MAIN model relates to HSM in that the former focuses on how affordances (traits of maps) can cue cognitive heuristics (mental shortcuts), that tend to be associated with heuristic processing. When someone processes information heuristically, they are generally less critical and are more likely to trust something.

There are three major factors that influence whether people process information heuristically or systematically: motivation, ability, and the modality of information. People tend to default to heuristic processing according to the *least effort principle*, which states that people are cognitive misers who prefer to exert as little effort as possible to arrive at a decision, so they generally have a preference for processing information heuristically (Chen and Chaiken 1999). However, a person's *motivation*, their desire to exert time and energy to process information, influences the type of information processing as well (Eagly and Chaiken 1993). In conditions of low motivation and low ability, people will tend to default to heuristic processing. Conversely, when someone is highly motivated and has the capacity to process information deeply, they will likely process a message systematically. Motivation is often operationalized in terms of *issue involvement*, which is defined as one's interest and investment in a topic (Mittal 1995). Issue involvement has been shown to affect credibility

judgments. When issue involvement (i.e., motivation) is low, more visually oriented modalities (e.g., videos, maps, graphics), may prompt people to process information more heuristically, resulting in more favorable credibility judgements (Sundar et al. 2017). Conversely, when issue involvement is high, visual modalities act like a catalyst and prompt people to process the information more deeply and be more aware of poor information.

The capacity to process information in depth, known as *ability*, can also affect which type of information processing is used. Ability can be affected by prior knowledge as well as characteristics of the medium, such as perceptual bandwidth (the number and type of sensory channels; Chen and Chaiken 1999; Sundar et al. 2015). When users have the potential to understand a message deeply, they will likely process the content of the message (i.e., engage in systematic processing) rather than relying on peripheral cues. Users are also more likely to engage in heuristic processing when dealing with information overload according to the Limited Capacity Model of Mediated Message Processing (LC4MP; Lang 2000). Therefore, when users deal with information overload or have low ability from other factors, they are more likely to have favorable credibility perceptions.

Finally, the type of information processing can be impacted by the modality of the information. Textual modality often requires more cognitive effort than visual modalities as individuals tend to carefully and analytically examine information via systematic processing, thereby making more thoughtful credibility judgments (Eagly and Chaiken 1993). In contrast, visual modalities can be interpreted more easily and appeal to our senses, so they are more likely to be processed quickly (via heuristic processing) and generally perceived positively (Sundar et al. 2021). Multimodal visuals may also lead to cognitive overload since there is extraneous content besides the message that must be processed (Lang 2000). Consequently, multimodal visuals are more likely to be processed heuristically based on LC4MP. Maps are a multimodal type of information that blends text and visuals, so people may tend to process them heuristically. The tendency for multimodal information like maps to be processed heuristically tends to lead to greater trust.

Halo Effect

The halo effect is the tendency for an individual to perceive a single positive trait of something and extend this positive impression to other traits and to their overall impression of something (Cooper 1981). The impression of credibility is a common outcome of the halo effect, as a user perceives a map to have positive qualities (attractiveness, for example), and then transfers that positive assessment to its credibility (Djafarova and Rushworth 2017; Sundar and Venkatesakumar 2013). In other words, perceiving a single positive characteristic about a source, message, or modality of information can lead to an overall positive perception that bolsters perceived credibility.

Mere Exposure Effect

The mere exposure effect posits that people will have greater familiarity with something and consequently more positive perceptions of something if they are repeatedly exposed to it (Janiszewski 1993). One such positive perception is trustworthiness. Lowry et al. (2007) demonstrated that repeated exposure to a website logo boosted perceived credibility and trust.

ARGUMENTS AS TO WHY MAPS ARE TRUSTWORTHY

I introduced each of the theoretical frameworks in the previous section because in this section I will apply these frameworks to explain why maps may be inherently trustworthy. I begin by outlining the arguments that researchers have made as to why people trust maps. Then, I address each argument individually by synthesizing the body of work behind the arguments. I buttress each argument with one or more of the theoretical frameworks discussed above. Specifically, I isolate traits of maps that link to said frameworks.

Five major reasons for why maps are more trustworthy than many other media of information have been proposed by researchers in cartography. Some of these reasons overlap and build on each other. First, maps are perceived as authoritative pieces of information, and individuals/entities that create them are viewed as being authority figures. Second, maps appear to be objective since they tend to be derived from numbers or other empirical data and appear to be complete representations of reality. Building on this, the visual and realistic nature of maps gives the illusion that what someone sees on a map is true. Maps are also ubiquitous, so they may be perceived as familiar and trustworthy. Finally, maps enable readers to see what they otherwise could not see, so their unique utility entices us to place faith in them.

The Authority of Maps

Maps may intrinsically invoke a sense of authority, since most popular Western maps produced in the last century or so have been made by experts at reputable institutions through rigorous means, and the data used to create those maps have been held to high-quality standards. The source of most of these maps has been government agencies, which were perceived as authoritative due to their tight quality control mechanisms, detailed metadata, and access to exclusive mapping technologies and data (Goodchild 2009; Muehlenhaus 2012). Likewise, Flanagin and Metzger (2008) point out that until recently, geographic datasets have been almost exclusively produced and shared by a centralized set of government agencies and other professional entities who adhered to strict data quality standards. These entities were instrumental in providing the public valuable maps that were also held to high standards; otherwise they risked enduring an erosion of trust (Flanagin and Metzger 2008). Therefore, maps were perceived as credible pieces of information since they were created by authoritative organizations.

Mapmakers themselves can also be seen as authorities, since they have unique expertise and purportedly communicate truthfully (Kent 2017). However, in recent years it has become relatively easy for anyone with internet access, sufficient time, and some computer skills to make widely distributed maps. In addition, traditionally "trustworthy" sources now face scrutiny and distrust due to the rise of post-truth politics where truth is less about fact and more about "belief." It remains unclear how these trends have influenced the perceived authority of maps. On the one hand, maps not only exhibit cultural and political authority themselves, but they also can imbue authority to those who leverage them (Shannon and Walker 2020). Shannon and Walker argue that anyone who creates—or even shares—a map may be seen as an authority figure that is also trustworthy. On the other hand, people may not have as great of a propensity to trust maps because of shifts in who makes maps and the zeitgeist around truth.

The MAIN model (Sundar 2008) posits that when the source of information is an expert or authority figure, that information will be perceived as more credible than if the information did not come from an authority. This *authority heuristic* is an agency affordance that may be cued by maps. In the 1900s, spatial information was largely provided by a small number of entities such as government agencies and professional organizations. Flanagin and Metzger (2008, 142) note, "credibility was granted based on the perceived authority of these few entities, which was generally agreed upon within the relevant scientific community and was (dis)proven over time." These sources produced lots of public-facing maps that were held to high-quality standards to maintain trust. Thus, people may exhibit a fallacy about maps in thinking that all maps are created by expert cartographers, and in doing so, placing higher trust in maps because of their historical prestige (Shannon and Walker 2020). Alternatively, when people see a map, they may not be able to imagine themselves as the maker of the map (since it is beyond their skill set) and they imagine the mapmaker as a more skilled, more professional, more *trustworthy* person than they (the reader) are.

Certain design elements of maps can cue people to perceive the map as being made by an expert. Muehlenhaus (2012, 363) found that authoritative-looking maps (e.g., maps that "look scientific, official, and magisterial") were perceived as the most trustworthy compared to three other aesthetic styles. Each aesthetic style that he tested with his participants had multiple variations in their design elements, so it is not possible to tease out the specific variables driving this result. However, the authoritative maps were unique in that they included multiple layers of data, had weak visual hierarchy, included all common map elements such as scale, legend, and data sources, and "typically follow[ed] the academic norms for graphicacy and map design" (Muehlenhaus 2012, 363). Future work needs to investigate to what degree each of these design elements can cue the authority heuristic. The inclusion of some map elements (i.e., legend, north arrow, scale bar) is the most logical cue for the authority heuristic since they are unique features of maps that signal to the reader that a cartographer is competent and an expert. Essentially, there is an expectation that a map has certain elements and if this expectation is violated, people may begin to scrutinize the map(maker) more and trust less.

The limited empirical evidence on trust and maps suggests that the relationship between the authority heuristic and trust may be moderated by characteristics of the source and the beliefs of a user. Skarlatidou, Wardlaw, et al. (2011) identified the source's reputation and reliability as a major component. Indeed, a follow-up experiment revealed that map users without a formal cartographic education primarily rely on peripheral cues, such as the presence/absence of a logo denoting the author's affiliation, to

determine the trustworthiness of a map (Skarlatidou et al. 2013).

For individuals with strong political beliefs, the authority heuristic may be cued only if a map is created by a source that conforms to their ideologies. Peck et al. (2019) asked rural residents of Pennsylvania to rank a set of two maps and eight other visualizations in terms of utility. Rural residents were recruited because they represented an understudied population that generally leans more conservative politically. After the rankings, researchers revealed the sources of the visualizations and asked participants whether they wanted to change their rankings. Just under half of participants changed their rankings and exhibited greater concern for whether sources were reputable. Interestingly, after the reveal, a map by the *New York Times* was ranked higher by more liberal individuals and lower by conservative individuals. Also, a map by *The Economist* was ranked roughly the same regardless of leaning, perhaps since it is perceived as a moderate outlet. Although the rankings were based on usefulness, qualitative responses indicate that trustworthiness was a major factor in the ranking process (Peck et al. 2019). Therefore, these results suggest that the authority heuristic may have led many participants to change their rankings of the maps depending on the perceived credibility of the source, derived largely from political congruence. Future confirmatory experiments should be conducted to validate these findings.

While this section outlines reasons as to why maps may be intrinsically authoritative, empirical evidence suggests that the source of the map is indicative of perceived authority and trust. Maps made by authorities may not be trusted if the "authority" is not reputable or is aligned against the prior beliefs and ideologies of a user. However, the aforementioned studies do not examine the relationship between trust and maps when the source of a map is obscured or hidden behind other layers on social media. These are fairly common characteristics of a typical map consumption environment (Lisnic et al. 2023), so future experiments should be designed in these conditions to maximize the external validity of the research.

The Objectivity of Maps

Maps may be perceived as trustworthy because they exhibit a façade of objectivity. The early years of cartographic research in the mid-1900s were characterized by the reduction of cartography to a perceptual science that focused on how maps served to unveil objective truths about the world (Kent 2018). While this paradigm has since been critiqued and largely abandoned (e.g., MacEachren 1995), many people, especially non-academics, may still view maps as containing objective information. One reason for this is that maps are products of numerical measurements and other seemingly objective data, so they appear truthful (Monmonier 1991). Numbers and statistics are generally perceived as trustworthy, since they are associated with objectivity and the absence of bias (Porter 2020). Therefore, if people view maps as products of quantitative data, this imbues them with an "aura of truth" that inclines people to trust them (Meier 2017). The corresponding psychological mechanism explaining this behavior is the halo effect. Numbers in a map's legend or features labeled with what appear to be hard data may cause the halo effect. Additionally, most maps include elements such as metadata, scale bars, or graticules that make a map seem as if it is a highly quantitative product.

Since I could not find any studies that explore this issue with maps specifically, I will discuss research on visualizations broadly. Over a quarter of the rural Pennsylvania participants in Peck et al.'s (2019) study of perceptions of visualizations elected not to change their rankings of how useful visualizations were after the authors revealed sources, because they believed that the data, and thus the visualizations derived from the data, were objective and trustworthy. The study included maps and other visualizations in the sample. Tal and Wansink (2016) found that including a simple bar chart in a pharmaceutical ad significantly increased the believability of the ad. This finding was attributed to graphs being imbued with a scientific aura that seems objective and credible, as they are made from quantitative data. Likewise, Kong et al. (2018) demonstrated that many users trusted visualizations that had misleading titles because they were blinded by the scientific aura of the visualization that seemed to be an impartial product of statistics. Instead of critically interrogating the title, people developed a positive impression of the data of the visualization, and expanded this impression to the rest of the visualization (including the title) (Kong et al. 2018).

Another trait of maps that lends them their perceived objectivity is their seemingly complete appearance. Tyner (1982) attributes people's (blind) trust in maps to the fact that they do not realize that all maps are incomplete; instead, they see maps as true and complete representations of reality. This is perhaps because, on the surface, maps

rarely draw attention to the many simplifications such as generalization, classification, and aggregation that actually make them paint a limited picture of reality. Even satellite maps that appear to capture a geography in full face limitations such as spatial and temporal resolution (Kent 2017). Again, the halo effect may be at play here with people's positive impression of maps' completeness extending to their overall perception of maps. In turn, this can bolster credibility.

The traits that make maps seem complete all revolve around mapmaking decisions and design choices. The symbolization choices for representing data can make a map seem complete, as data are often represented without any missing pieces, and uncertainty in the data is rarely shown. The seamlessness and certainty of mapped data make maps seem to be complete and credible representations. Finally, the inclusion of borders make maps appear organized, and provide bounds for space (Kelly 2019). Effectively, maps provide familiar context that allows readers to form a coherent representation of reality.

The Realism of Maps

Maps not only appear complete, but they give the illusion that what they portray is reality, even though that is not the case. This illusion works since maps convey "to the mind a vivid, true picture of the distribution of certain phenomena on the earth's surface that could not be obtained in any other manner" (Boggs 1947, 474). These visuals coax us into trusting maps because they generally fit what we would expect reality to look like. Overall, "the visual character of maps reinforces this perception [of objectivity]" as people regard maps as reality and not representations of space (Churchill and Slarsky 2004, 23). Since people can see the data in a realistic manner, people will be predisposed to trust it.

This argument can be attributed to the *realism heuristic,* which posits that "seeing is believing"—in that information that looks realistic will be perceived as more credible since it appears to be reality (Sundar 2008). According to the MAIN model, the realism heuristic is cued by visual modality affordances. In the following few paragraphs, I outline the specific affordances of maps that may cue the realism heuristic.

First, the particular shapes used to represent boundaries, landmarks, and other features on a map will be familiar to many of its readers, and will help them orient themselves to the mapping landscape. Encountering these features can trigger rich associations and memories pertaining to a particular place (Francaviglia 1995). Consequently, people may feel immersed in the map and judge it as more real.

Maps may also cue the realism heuristic if they include satellite imagery. As Dodge and Perkins (2009, 2) note, these high-resolution glimpses at Earth's surface offer "a heightened sense of pictorial realism, a heterogeneity of colorful patterns, and a sense of apparent naturalism." These images are highly realistic and thus may give the impression that they are truthful. Whether they are standalone, or they constitute the background of the map in terms of visual hierarchy, satellite images likely can cue the realism heuristic.

Third, thematic maps, which use different visual variables (e.g., color value, shape, size) to communicate attributes about different geographic features, cue the realism heuristic by superimposing data visualization on top of familiar geographic features. Hence, the data visualized in maps appears inextricable from the geographic features they correspond to (Monmonier 1991). Since people can actually see information being mapped to particular places, they are more likely to believe it as true and credible. In other words, unlike textual descriptions of geography, maps provide a visual confirmation of the information that seems concrete and representative of the real world.

Finally, most maps make use of a bird's-eye view, in that the perspective of the visual is as if the map reader is gazing down at Earth from above (Kelly et al. 2022). As Hillis (1994, 3) explains, "Perspective maps such as bird's-eye views gain power through their seemingly natural representational structuring of reality." The bird's-eye view gives the illusion that the reader is viewing something that is real and true even though the map is highly authored and abstracted. Therefore, the bird's-eye view characteristic of maps may cue the realism heuristic.

The Ubiquity of Maps

People may place (excessive) trust in maps because maps are so ubiquitous. For example, navigation maps are a vital part of many people's daily lives and are increasingly relied on (Laor and Galily 2022). Trapsilawati et al. (2019) demonstrated that users place high levels of trust in two of the most popular wayfinding applications: Waze and Google Maps. Users tended to place more trust in the application that they used more, potentially indicating that ubiquitous use fostered trust. Even though navigational maps are quite different than thematic maps and satellite

images, people may extend their trust in navigational maps to other map types because of their similarities.

Overall, the main psychological mechanism that causes our frequent use of maps to create trust is the *mere exposure effect*. The mere exposure effect posits that people will have greater familiarity with something, and consequently more positive perceptions of it, if they are repeatedly exposed to it (Janiszewski 1993). Since familiarity has been demonstrated to be an antecedent of trust, greater familiarity with maps may lead to heightened trust (Gulati and Sytch 2008). So, the abundance and general reliability of maps as navigational tools leads to a perception of general trustworthiness.

The Utility of Maps

Finally, maps often provide critical information that can only be effectively communicated through their unique spatial representation. Consequently, people are inclined to put faith in (i.e., trust) maps, because they must rely on them to acquire certain information about space and place. Since many of the things that maps depict are not observable or accessible in day-to-day life, maps are intriguing and prompt us to exercise our faith in them (Kent 2017). This argument is echoed by Boggs (1947) and McGranaghan (1999). These authors articulate that it is impossible to fully experience the complexity of the world, so we must place trust in something like maps that can depict aspects of reality that we cannot directly observe. This may be attributed to both the halo effect and the realism heuristic. On the one hand, if people find maps useful to orient themselves to space and place, this positive perception may extend to a perception of trustworthiness (Cooper 1981). On the other hand, in the absence of being able to directly observe the phenomenon a map represents, seeing it on the map makes it seem real and credible (Sundar 2008).

CONCEPT EXPLICATION

Concept explication is the process of surveying the theoretical and operational definitions of a particular concept in the literature to identify commonalities and distinctions among definitions, and to distill the concept into its defining characteristics. Since trust has many different meanings across disciplines and within the discipline of cartography, it is necessary to establish a robust and consistent meaning for the context of maps. This ensures researchers are studying the same thing and using consistent terminology (Appelman and Sundar 2016).

The main component of concept explication is a *meaning analysis* that involves "boiling the idea down to its essential elements" (Chaffee 1991, 26). While meaning analyses are not common in the cartography/GIScience literature, they are frequently performed in communication literature to clarify what constitutes a particular concept, and what does not. I model my approach after prior examples by identifying definitions of trust and categorizing these definitions before paring them down to isolate key aspects of trust (Appelman and Sundar 2016; Kiousis 2002; Molina et al. 2021). These aspects will springboard the development of a robust theoretical definition of trust in the context of maps.

The rest of the section is organized as follows. First, I describe three categories of theoretical definitions. Next, I explore the similarities and differences among these groups of definitions. I also briefly discuss definitions of media trust. Finally, I propose the key components underlying trust in maps and operationalize these components into a robust definition.

CATEGORIES OF THEORETICAL DEFINITIONS

I extracted theoretical definitions of trust/credibility from over twenty articles on cartography, as well as those on non-spatial information visualization. These definitions can be found in Table 1. Only about a third of these papers explicitly defined trust. The rest offered implied definitions or did not provide any semblance of a definition. In this section, I outline the three major groupings of trust definitions, including belief in correctness, dependence on maps, and confidence in information produced or conveyed.

Belief in Correctness

Within cartography, trust is largely defined as someone's belief that a map conveys geographic information that is truthful to reality (Muehlenhaus 2012; Tyner 1982). Trust is also defined as how certain an individual is that the map communicates correct geospatial information (MacEachren et al. 2012; Schiewe and Schweer 2013).

Paper(s)	Definition Type	Concept Captured	Definition	Viz / Map
Mason and Azzam (2019)	Absent	Credibility	-	Viz
Zheng and Ma (2022)	Absent	Credibility	-	Viz and Map
Meier (2017)	Implied	Credibility	Perceived qualities of expertise and trustworthiness	Viz and Map
Li et al. (2018)	Implied	Data Credibility	The perceived accuracy and trustworthiness of data	Viz
Link et al. (2021, 577), Appelman and Sundar (2016, 63)	Defined	Message Credibility	"An individual's judgement of the veracity of the content of communication"	Viz
Xiong et. al (2019)	Absent	Trust	-	Map
Kübler et al. (2020)	Absent	Trust	-	Map
Platte et al. (2016)	Absent	Trust	-	Viz
Guo et al. (2019)	Absent	Trust	-	Viz
Mohanty (2022)	Absent	Trust	-	Viz
Zhao et al. (2023)	Absent	Trust	-	Viz
Peck et al. (2019)	Absent	Trust	-	Viz and Map
McGranaghan (1999, 4)	Defined	Trust	"accepting that the cartographer has tried to communicate accurately and was capable of doing so to some adequate approximation"	Map
Schiewe and Schweer (2013, 60)	Defined	Trust	"The subjective certainty regarding the correctness of a map"	Map
Christen et al. (2021, 2)	Defined	Trust	"the validity of a user's conclusions made from a data display"	Map
Mayr et al. (2019, 25), Padilla et al. (2023, 12)	Defined	Trust	"the user's implicit or explicit tendency to rely on a visualization and to build on the information displayed"	Viz
Boukhelifa et al. (2021, 46)	Defined	Trust	"Trust is the level of confidence and belief that the system is presenting the most relevant information"	Viz
Lin and Thornton (2021, 22)	Defined	Trust	"how much do you believe that the information described by the graph is accurate"	Viz
Burns et al. (2022, 3427)	Defined	Trust	"how much they believe the information communicated by visualizations is accurate"	Viz and Map
Tyner (1982)	Implied	Trust	Accepting the information conveyed in a map as true and complete	Map
Skarlatidou et al. (2011)	Implied	Trust	Willingness to rely on a web GIS tool	Map
Muehlenhaus (2012)	Implied	Trust	Believing what is shown on a map as reality	Map
Skarlatidou et al. (2013)	Implied	Trust	Willingness to depend on a web GIS tool	Map

Table 1. Breakdown of trust/credibility definitions. Continues on next page.

Paper(s)	Definition Type	Concept Captured	Definition	Viz / Map
Gartner (2022)	Implied	Trust	the confidence in or reliance on a map	Map
Joslyn et al. (2013)	Implied	Trust	Willingness to rely on and use information visualized	Viz
Dasgupta, Burrows et al. (2017)	Implied	Trust	the degree of confidence in a visual analytics tool	Viz
Kong et al. (2019)	Implied	Trust	Believing a visualization was unbiased and appropriate	Viz
Dasgupta, Lee et al. (2017, 274)	Present	Trust	"self-calibrated degree of confidence in their analysis outcome that is produced in course of their interactions with any data analysis medium."	Viz
MacEachren et al. (2012, 2498)	Defined	Trustworthiness	"Source dependability or the confidence the user has in the information"	Map
Antifakos et al. (2006)	Absent		-	Viz

Table 1, continued. Breakdown of trust/credibility definitions.

Similar definitions exist in information visualization, with Kong et al. (2019) characterizing trust as an individual's belief that the information that a visualization presents is accurate and appropriate. Accuracy is echoed by Lin and Thorton's (2021, 22) definition of trust: "how much do you believe that the information described by the graph is accurate." Together, these themes conceptualize trust as an individual's belief that the information underlying a map is accurate and/or truthful.

The theoretical definitions of credibility used in visualization research are like those of trust, but they revolve around judgements of trustworthiness instead of the act of trusting. Indeed, Meier (2017) and Li et al. (2018) define credibility in terms of the perceived trustworthiness, accuracy and/or expertise of a visualization. Link et al.'s definition of credibility (2021) focuses on the veracity of the visualization content. Hence, these definitions differ from trust in that they focus on the perceived quality of the visualization in terms of trustworthiness and/or other attributes.

Dependence on Maps

Trust is also defined as the state of someone relying/depending on a map for information or decision making, or their level of willingness to do so. For instance, Gartner (2022) defines trust as the confidence in or reliance on a map. MacEachren et al. (2012) take a slightly different approach by characterizing trustworthiness as the dependence on an information source (i.e., the map and/or mapmaker). This definition hinges on the argument that it is impossible to experience all the world has to offer, so we must place trust in someone (mapmakers) and/or something (maps) to selectively communicate key information (Kohring and Matthes 2007; Usher 2020). As McGranaghan (1999, 4) puts it, "trust is accepting that the cartographer has tried to communicate accurately and was capable of doing so to some adequate approximation." Thus, trust in maps entails relying on the mapmaker and thereby the unique geographic information encoded in maps. Two definitions, by Skarlatidou et al. (2013) and Skarlatidou, Haklay, and Cheng (2011) emphasize the choice of trusting a map; the *willingness* to rely/depend on a web GIS application.

Reliance is not only a key component of trust definitions in cartography research but also in information visualization research. Mayr et al. (2019, 1) define trust as "…the user's implicit or explicit tendency to rely on a visualization and to build on the information displayed." This definition is also employed by Padilla et al. (2023). Featuring reliance/dependence in a trust definition is predicated on conceptualizations of trust in interpersonal relationships. Accordingly, trust relationships involve a trustor who depends/relies on a trustee to act in their best interest (McKnight and Chervany 2001).

Confidence in Information Produced or Conveyed

A final group of definitions revolves around confidence in the tool or system that facilitates analytical reasoning through exploratory information visualizations called *visual analytics*. Dasgupta, Lee et al. define trust as the "…self-calibrated degree of confidence in [the user's] analysis outcome that is produced in course of their interactions with any data analysis medium" (2017, 274). Building on this, Dasgupta, Burrows, et al. (2017) define trust in terms of confidence in a visual analytics tool. Hence, trust is about how confident users are that a visual analytics tool is steering them in the right direction to generate insight. Similarly, Boukhelifa et al. (2021) conceive of trust as the confidence that a visual analytics tool is providing a user with the most useful information.

THEORETICAL DEFINITION COMMONALITIES AND DISTINCTIONS

The definitions relating to beliefs about a map being correct raise an important question: since all maps are simplifications of reality that suffer from distortions (Monmonier 1991), what is a correct map? In other words, what is an accurate, truthful, and/or appropriate map? Maps are objects of power relations, so the correctness of a map is highly individual and subjective (Del Casino and Hanna 2005). Therefore, a definition of trust in maps should account for the subjective nature of an individual's decision as to what is truthful and what is not.

Each of the three groups of definitions include reliance on the map/visualization to varying degrees. Reliance is the greatest for the group that bases trust solely on whether a reader depends on maps. Conversely, when trust is framed in terms of confidence, reliance seems relatively low since confidence is fundamentally a question of likelihood, and thus it embraces uncertainty. Lastly, belief concerns a mental state that is based on accepting something as true. In accepting that a map's information is true, someone must rely on it to a degree. However, reliance is usually dictated by actions which may or may not happen as a result of believing something.

Media Trust

It is valuable to explore definitions of media trust, as media function to selectively communicate information to the public much like maps do (Usher 2020). Hanitzsch et al. (2018, 5) define media trust as "the willingness of the audience to be vulnerable to news content based on the expectation that the media will perform in a satisfactory manner." In other words, trust entails accepting the information that the media provides as true, even though it could be wrong; and in doing so, people open themselves up to the possibility of being misled or misinformed. Kohring and Matthes (2007) define trust as the expectation that news media selectively communicate information that enables an individual to successfully orient themselves to the complexities of modern society. Here, vulnerability is implied since an individual expects news media to provide timely, accurate, and relevant information that enables that individual to make informed decisions and orient to the ever-changing world. A final definition of trust was synthesized by Strömbäck et al. based on several prominent works on trust in media studies: "the relationship between citizens (the trustors) and the news media (the trustees) where citizens, however tacit or habitual, in situations of uncertainty expect that interactions with the news media will lead to gains rather than losses" (2020, 142). Hence, trust involves a favorable expectation, based on past experience, toward news media in communicating accurate and reliable information.

Each of these definitions emphasize that trust entails believing that the information communicated by media has the audience's best interests in mind. Trust is also an inherently risky action but is necessitated by the desire for more knowledge about the world.

KEY COMPONENTS OF TRUST IN MAPS

An essential component of trust in maps is choosing to rely on visualized information, with many definitions noting that trust is a deliberate decision or tendency to depend. Reliance entails vulnerability, which is a key component of institutional and interpersonal trust.

This vulnerability is tempered by another key component—positive expectations—which in the context of maps translates to believing that the map was ethically and accurately made. Many definitions emphasize the accuracy or correctness of a map, while others focus on truth, which is inseparable from ethics, as no map tells a complete truth (Del Casino and Hanna 2005). What constitutes truth and accuracy depends on an individual's worldview as well as the larger sociocultural context in which mapped knowledge is produced and consumed. Further, the truth

an individual arrives at in reading a map derives from their interpretation of it. Maps do not communicate a single message, rather they are imbued with multiple layers of meaning that come to life through a map reader's individual interpretation of information (MacEachren 1995). Hence, trust is not in the information itself but rather how an individual interprets the information from the map.

While many visual modalities exist (e.g., photos, videos), maps are unique in that they function as representations by employing abstract, visual symbols to relay information about geospatial realities. These symbols are shaped by cartographers who transform numerical, verbal, and other data into a visualization that is grounded in space. Maps do not appear contrived, but convey just a single possible representation of reality, depending on the choices of a cartographer and the subsequent interpretation of map readers. Therefore, trust in maps hinges on the visual representation that a cartographer produced.

Each of these core components is reflected in the definition of trust in maps that I offer:

> ***the willingness to rely on the map contents based on the expectation that the representation of geographic phenomena is accurate and unbiased***

This definition is not meant to be final, but rather serve as a starting point for conceptualizing trust in cartography.

CONCLUSION

In this article, I have examined the concept of trust through a cartographic lens. I synthesized the main five arguments of researchers as to why maps may be inherently trustworthy. These arguments revolve around the purported authority, objectivity, realism, ubiquity, and utility of maps. I then expanded upon these arguments by connecting them to relevant theories that may explain why maps may be inherently trustworthy. Most notably, the MAIN model offers explanations as to why maps may be trusted to a greater degree than other types of information due to their unique modality and agency affordances.

Additionally, I conducted a concept explication to explore the meaning of trust in maps. Different theoretical definitions of trust in maps (and visualizations) were compared and grouped to identify the most important elements. I integrated these elements into a single, cohesive definition that embodies trust in maps.

There are several limitations of this work that can be addressed in future work. While I bridged the gap between theory and arguments as to why maps may be trustworthy, it remains unclear if these arguments, and the backing theory, are valid. Many publications I used to synthesize arguments as to why maps are trustworthy are from the mid to late 1900s. Trust in maps may be drastically different today due to our reliance on wayfinding applications, the emergence of post-truth politics, and the digital media consumption environment. Therefore, we need to empirically test whether the unique traits of maps identified in this paper do indeed bolster trust and if it is because of the theorized mediators. For example, do satellite maps foster trust because they look real?

Another limitation is the use of concept explication as it is a challenging and inherently subjective process that arrives at definitions and meanings based on an individual's critical evaluation of the literature. Other researchers should perform concept expectations on trust in maps using a similar body of works and see if the key pieces of trust and the resulting definition remain similar.

The sample of works used in the concept explication present two limitations at tension with one another. On the one hand, inferences drawn from literature outside of cartography (information visualization and media studies) may not be applicable. On the other hand, I did not draw from sociology, anthropology, and other related fields that also have extensive work on trust. A future study should investigate whether conceptualizations and definitions of trust in sociology are useful for cartographers. Another avenue is to assess the suitability of the proposed definition of trust in maps using focus groups or other means.

This paper lays the groundwork for answering the longstanding question of why/if people trust maps more than other media. Determining if maps are trustworthy is crucial to both combatting misinformation spread by maps

and leveraging maps in science communication campaigns. Moreover, isolating the specific characteristics of maps driving this tendency will help enrich theory in psychology alike. Finally, defining trust in the context of cartography will help ensure that researchers are talking about and studying the same concept.

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