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Psychologists in the 1960s and 70s postulated the concept of prototypes as fundamental to an individual's ability to organize and categorize information. Cartographers in the 1990s attempted to determine what constitutes the map prototype and what graphic elements move objects "nearer" to that prototype. It has been suggested that the rise of Google Earth, greater familiarity with satellite imagery, and web mapping services may have altered the current map prototype.

This study presents findings from two experiments. The first replicates earlier cartographic studies to determine the relative importance of select graphic elements (labeling, cartographic iconography, verticality of perspective, etc.) in establishing the map prototype. The subjects for the study were undergraduate students who were shown a series of images and asked to rate "how map-like" the image was on a scale of 0 to 10, with 0 indicating nothing in common with a map and 10 being totally map. Results indicated that graphic representations that were most map-like were road atlases, online street maps, and reference maps. Characteristics that were considered to increase mapness included verticality, labels, real, urban and drawn. Recorded satellite images did not influence level of mapness.

DEFINING THE MAP: UTILIZING CLASSICAL CATEGORIZATION AND

PROTOTYPE THEORY

by

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APPROVAL PAGE

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CHAPTER I

INTRODUCTION

Beryl Markham, quoted by noted map historian J.B. Harley (2001), eloquently declares the following:

> A map says to you, “Read me carefully, follow me closely, doubt me not.” It says, “I am the earth in the palm of your hand. Without me, you are alone and lost.” (p. 150).

But what makes this graphic representation that we are to trust and follow so carefully and closely a map? The most general answer is, “It depends.” For what purpose is the graphic created? Is it intended to convey accurate information about spatial relationships, or to inform public debate? Who will read the map? Is the map reader a novice or a seasoned professional? Where will the map be used? What data is available for the composition of the map? Cartographers and map historians have attempted to answer the basic question of *what makes a map, a map* using a variety of frameworks. Complicating the search for the answer is the fact that maps have changed over time due to technological advances in how maps are produced and viewed. Early on maps were hand drawn to represent distance and location, today, orbiting satellites record detailed images of the terrain that can and are used for those functions.

Cultural differences on the context of mapness are dependent on the degree of the operating functionality of the map, David Woodward (1998) explains that maps vary greatly in form and function among indigenous societies. In other words, maps are fundamental in understanding how members of a certain community or society view and represent their spatial awareness. Woodward also states that maps are more than wayfinding devices. “Maps have shaped scientific hypotheses, formed political and military strategies, formulated social policy, reflected cultural ideas about the landscape, and served as agents of social and political power (p. 33)”.

While little experimental research has been undertaken to determine what the general public believes a map to be, much has been written and debated by cartographers concerning what constitutes a map. Early definitions of the map focused on necessary traits, while later definitions of a map were based on how an image was used. There are two approaches to defining a map which mimic the classical categorization theory put forth by psychologists. Eleanor Rosch (1975) first put forth the idea that when attempting to categorize an object or experience, people seldom rely on abstract definitions of categories. Instead they compare the given object or experience with an exemplar that they believe is the “prototypical” object or experience which best represents a category. These prototypes can be formed by either elements (characteristics) or functions (what does it do).

Cartographers have focused on creating definitions of maps which can be utilized to include or exclude representations. While not directly attempting to uncover a map prototype the multiple definitions developed by cartographers may be quite useful in attempting to gather the typical graphic elements or map functions that one would likely find in a map prototype.

Maps have been defined in a variety of ways. Raisz (1962) defines a map as a "selective, symbolized, and generalized picture of some spatial distribution of a large area, usually the earth's surface, as seen from above at a much reduced scale. Most maps are lettered and related to a coordinate system (p. 32)." Vasiliev (1990), summarizing various historical definitions of maps, finds frequent references to "representation (usually on a plane surface) of the Earth's surface, geographic pictures on which lands and seas are delineated according to the longitude and latitude, and graphic representations at an established scale, of natural and manmade features on or under the surface of the earth." Others have broadened the definitions of maps to include the virtual, computerized, and/or digital representations of fantasy realms, cyberspace, and 3-D images. Harley and Woodward (1987) offered a broad definition that encompassed these various mapping forms. They note that "maps are graphic representations that facilitate a spatial understanding of things, concepts, conditions, processes, or events in the human world (1987, xvi)."

Robinson and Petchenik (1976), in an attempt to define the essence of a map, maintain that any general definition of a map must be based on two critical elements: representation and space. For them, the general definition of a map must be based on "its being simply a representation of things in space (p. 15)." The meaning of space in their conception is further refined as the "milieu" to reflect the notions of "place" and "area", while representation is denoted as graphic, resulting in a map as being a "graphic representation of the milieu."

An essential feature of Robinson and Petchenik's conceptualization that has bearing on the development of the map prototype is the notion of *percipient*, or the one who looks at a map. A *percipient*, a term used by those who study perception, is one who looks at a map to add to their "fund of spatial knowledge or acquire additional meaning (p. 20)." A map then is a system of communication between the cartographer and the percipient, and like any system of communication, it is important to study the characteristics of both the information sender and the information receiver: to study the characteristics of the information sent (via the map) and features that are necessary for the map to be perceived as "map" by the percipient. Studies of map *percipients* have included a variety of populations, even those who have limited language ability, and have discovered that mapping is a cultural and cognitive universal (Blaut et al., 2003). While mapping may be a cultural universal the products created often look very different from one culture or time to another and one would expect that the "prototype" would vary accordingly. Even within the same culture the prototype for some objects has been shown to vary between children and adults and between genders.

This study attempts to further our understanding of what representation(s) serve as the map prototype for American college students and to determine the relative importance of various graphic elements or functions in forming an objects level of "*mapness"*, the degree to which a graphic representation fits one's definition of a map (Vasiliev et al., 1990). This current research attempts to extend this body of work to help define which representation(s) may serve as map prototypes and to assess what characteristics and/or functions of an image are inherent in the map prototype.

Additionally this study will investigate how changing technology, such as satellite imagery, digital elevation models, and online mapping is influencing the evolving notion of the map prototype of American college students.

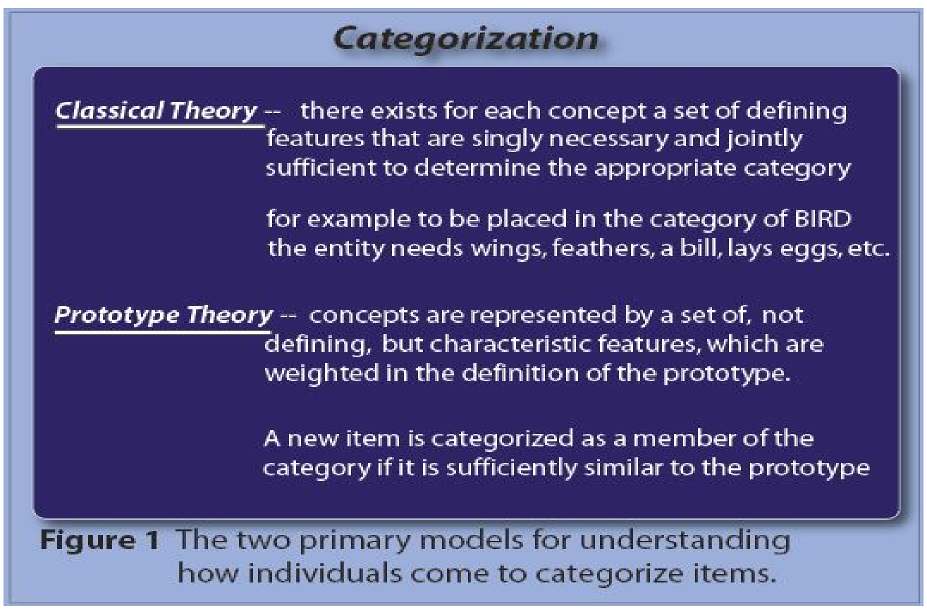
CHAPTER II

LITERATURE REVIEW

2.1 Categorization Theory

Categorization and prototype are constructs of cognitive psychology (Figure 2.1.1). According to Rosch, (1978), the notion of categorization is that the category system "provides maximum information with the least cognitive effort (p.2)." The second principle of categorization asserts that material objects of the perceived world possess a high correlational structure (p.3).

Figure 2.1.1 Two Types of Categorization Theory



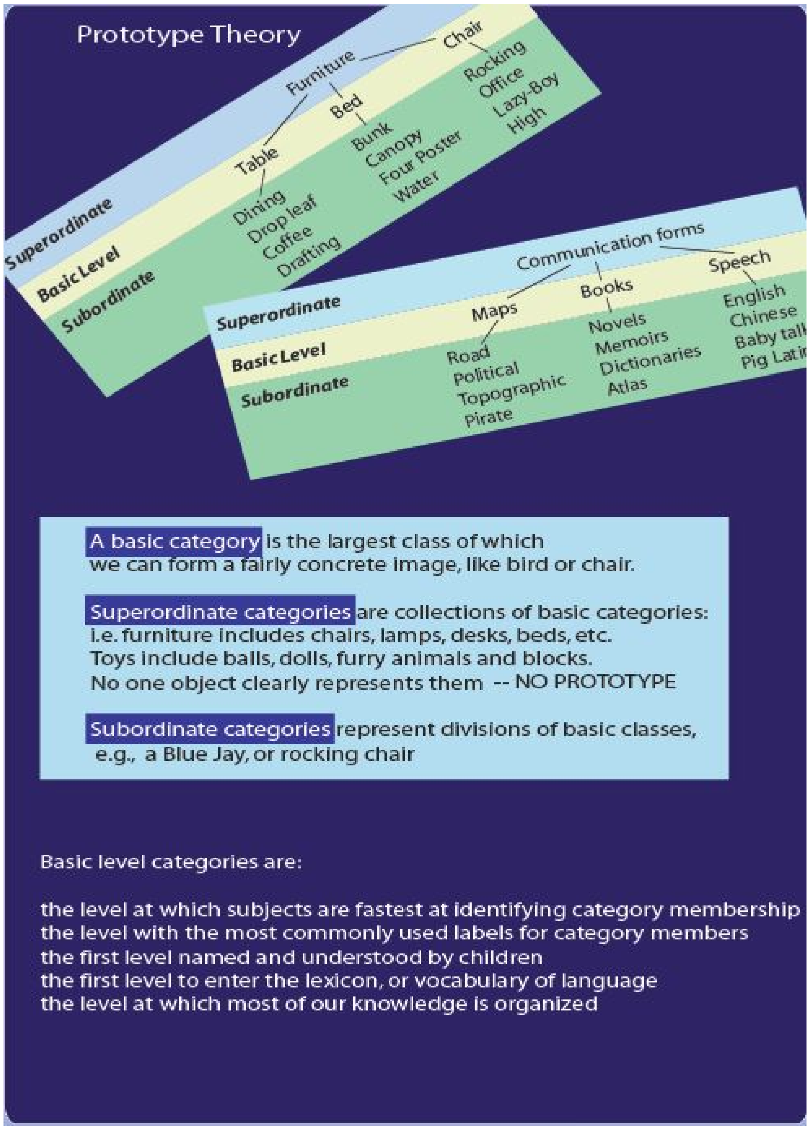
A category can be defined as a collection of objects that are equivalent in both form and function (Rosch and Mervis 1975). Rosch notes that there is a vertical dimension of categories in that “there is generally one level of abstraction at which the most basic category cuts can be made (Rosch, 1978).” To fit, an object must be considered equivalent to other members in the category as well as distinctly different from members in other categories (Patton et al., 2005)

Three levels exist within this cognitive conceptualization: the superordinate category, the basic-level category, and the subordinate category. For purposes of explanation one can look to the world of dogs for understanding. The superordinate category is found at the top of the taxonomic chart and displays a high degree of generality and has a high degree of inclusion. For this example, the superordinate category would be mammal. The next categorization, basic-level category, has members that are relatively homogenous but is also the level where the differences between entities are most readily perceived (e.g., cats vs. dogs). This level maximizes the number of attributes shared by members of its categories and minimizes the number of attributes shared with other categories. The subordinate category is at the bottom of the taxonomy and displays a low degree of class inclusion and a low degree of generality. Using the dog example, within this category one would find different types of dogs (e.g., Golden Retrievers, Beagles, Chihuahuas, etc). Simply stated, superordinate category (mammals), basic level category (dogs), subordinate category (Golden Retrievers). Extending this taxonomy to the world of maps, the *superordinate* category might be described as graphic informational representations, with examples of basic-level members being maps, photographs, charts, block diagrams, and scientific illustrations. For maps the least inclusive category, the *subordinate* category, would be the division of maps into various forms such as street maps, thematic maps, or topographic maps. The basic-level category carries the most information and member objects share attributes that consistently allow the category to be predicted correctly (Rosch, 1978). Attesting to the importance of basic-level categorization to our understanding of how to organize the world is the idea that it is the earliest learned and utilized categorization level. A child first recognizes the differences between a “kitty” and a “doggy” without knowing the concept of mammals or of various breeds of cats or dogs. Within Rosch’s theory there exists also a horizontal dimension of internal structure of categories, also known as *prototypes*.

2.2 Prototype Theory

The concept of prototypes as fundamental to an individual’s ability to organize and categorize information was postulated by psychologists in the 1960’s and 1970s (Figure 2.2.1). Robert Lloyd, a cartographer (1994) defines a prototype as “...a category of an object that is stored in our memory as an abstraction (p. 418).” Rosch and Mervis (1975) assert that prototypes represent a strong family resemblance among all objects of a category, and thus exaggerate the existing structure of the category members so that attributes of some members are thought of as characteristic of all members. Cartographers (Patton et al., 2006; Vasiliev et al., 1990) have attempted to determine what constitutes the map prototype and what graphic elements and or functions move objects “nearer” to that prototype.

Figure 2.2.1 Prototype Theory



Clearly prototypes can change over time. The prototype of the car in 1930 may have been the Model T Ford, while today it may be more like a Toyota Corolla. Has the map prototype changed over time? If so, what has driven that change? The last few decades have seen unprecedented change in how maps are produced, what they look like, and how they are used. Google Earth, MapQuest and other online mapping services allow the map user to be the map maker, creating custom images using the specific palette of options provided by the service. As a result while virtually every map created using these services is unique in terms of the geographic space portrayed they all have a highly consistent and easily recognizable “look” Online map animations, the linking of map locations to photographs have changed both the look and the function of maps. Maps that once were 2-D now offer 3-D versions that highlight landmarks as points of wayfinding reference (Liao and Dong, 2016). Thus it is likely that the prototype has changed over the past decade

Previous studies indicate that the category of *map* is defined by a prototypical map (for many it is the road or general reference map) and prototype theory predicts that all other graphic representations encountered are compared to this prototype prior to assigning the representation to the *map* category. Prototype theory also suggests that the prototype contains all of the elements considered typical or standard of the basic level item in question. Lacking one or two of the standard elements may not preclude an item from being a member of a basic level group but that item would not be a prototype. Vasiliev et al (1990) found that that map elements such as labels and symbolization, the variation of perspective and scale, subject matter and place familiarity, and function all influence a person’s assessment that a graphic representation fits the definition of a map. Lack of one or more of these elements may not preclude if from being a map, but would move the item away from the prototype. Movement too far from the prototype would mean no longer being considered a map.

In a paper presented at the North American Cartographic Information Society (NACIS) Patton, et al (2004) looked at a series of elements and functions that increase the level of *mapness* of an object. Factors increasing mapness included labeling, a high viewing perspective, and familiarity with the shape of the area portrayed. This study also suggested that general reference maps and road maps may serve as prototypes. (Patton et al., 2006). In this study subjects were shown a series of images and were asked to rank each image on a scale of 0 to 10 with 0 being the least maplike to 10 being the most maplike. Images included in this study included road maps, reference maps, thematic maps, organizational charts, topographic maps, satellite images, cartograms, diagrams, and foils. In a second paper presented at the annual meetings of the Association of American Geographers Patton and Nelson (2006) continued their earlier work by comparing how experts in cartography rated the same images shown to the novice map readers in the earlier study. In general, experts ranked all images with any map characteristics as having a higher level of mapness than their novice counterparts.

2.3 Previous Map Studies

2.3.1 Map Percipients

Cartographic research has long used the paradigm of the map as a communication system (Kolacny, 1969; McEachran, 1995). As a result, studies have looked at both the traits of the map and those of the map reader or as Robinson and Petchenik (1976) refer to them, the map *percipient*. The abilities of various map percipient groups including those based on age, gender, culture, or level of expertise has been well documented. For example, Blaut et al. (2003) determined that children between the ages of three and six years old were able to identify a vertical, black-and-white air photo as an iconic map and could use small toy cars to make their way on the roads of the map to a specific location.

With regard to cultural differences, Chang and Antex (1987) investigated the differences between Asian and American map readers and found that males performed significantly better than females on reference, topographic, and street map reading, both in American and Taiwanese cultures. He also showed that Taiwanese map readers of both genders outperformed their American counterparts using topographic using topographic maps. These findings have been criticized, however, due to the marked differences between the samples—the Taiwanese sample came from an elite private school, while the American sample was from a public school.

Liao and Dong (2016) found that undergraduate males using a three-dimensional map paid more attention to landmarks in the environment and performed better at map reading than when using the conventional two-dimensional map. Females showed no such difference. Females, on the other hand, paid more attention to landmarks than males. Gilmartin and Patton (1984) investigated gender differences, finding that the main gender-based differences were found in the younger age groups, with boys performing better than girls. They found the advantage shown by boys to be relatively short lived generally disappearing by the time that the children entered the 4th grade. Among college students map-use scores for females and males were statistically identical.

While differences in map audience have been found, cartographers and anthropologists agree “that mapping, or map-like modeling, is a basic and necessary part of the strategy used by nearly all people, in almost all cultures, to cope successfully with the macro environment (Blaut et al., 2003, p.181).” While the studies on map percipients demonstrated that there were differences between various map reading audiences, none of the studies addressed the question of whether there were differences in how each group defines the map or in the prototypes that they used to compare other objects to see if they were also maps.

2.3.2 Map Elements

Savric, et al. (2015) sought to identify the preferred world map projection among map-readers, and to define what graticule characteristics map-readers preferred. As noted by the authors, over the centuries cartographers have developed multiple ways of representing the spherical world on the flat page. Projections are systematic arrangement of lines drawn on a plane surface which correspond to the meridians and parallels of the curved surface of the earth. Ways in which the maps differ depend on the presentation of meridians (as curved or straight lines), parallels, poles, corners. Previous work has focused on the preferences of general map readers, using college populations as subjects. Citing the limited generalizability of these findings given the sample, the authors sought to extend their subject pools by recruiting from professional (professional and academic cartographers, map projection and GIS experts) and nonprofessional/casual map readers to determine the map distortion properties and shape of the projection found pleasing by the different groups.

With regard to results, the authors found that most general map-readers preferred the Robinson and Plate Carrée projections over the other projections. These two maps have straight pole lines, a feature that distinguishes them from the other maps. General map readers tended to dislike ellipse shaped projections, as well as those containing interrupted projections. Professional map readers also preferred the Robinson projection. Results regarding the more specific features of the map projection yielded results indicating a preference for elliptical shapes for meridians, straight over curved parallels, pole lines for pole representation, and no preference for edged vs. curved pole line corners. While this research does not speak to map prototype, it does provide insight as to what map readers prefer. What is unclear is how preference is related to prototype. Did the subjects prefer one projection over another because it more closely resembled their prototype of the world's shape and landmass position, and by extension, what they would define as map?

In another study of map projections, Battersby et al. (2015) investigated the idea that due to its widespread use, the Mercator projection may have become the *de facto* prototype of the world's landmass shapes and relative sizes. The Mercator projection is well on its way to becoming the accepted standard for online mapping (Battersby et al., 2015). For most cartographers this is seen as particularly troubling because of the high degree of areal distortion inherent in the Mercator projection.

To date, the most important cartographic research directly investigating the concept of the map prototype is that of Vasiliev, et al. (1990). In an attempt to determine the distinguishing features of what makes a map, a map, she devised an approach that involved showing visual stimuli to subjects for the purpose of classifying or determining whether the stimulus picture was a map. Fifty-one pictures were chosen to fit one of three categories: definitely map, definitely not map, and intermediate stimuli. Each of the pictures were assessed for the presence or absence of 33 map characteristics/elements, including such characteristics as legend, scale, symbology, perspective, and medium. Twenty-six college students and faculty were shown the 51 pictures and asked to rate the stimuli on the following scale: “(1) definitely a map, (2) probably a map, (3) can’t tell (ambiguous stimulus), (4) probably not a map, and (5) definitely not a map (Vasiliev et al., 1990).” Based on the findings, five categories of map elements were determined to make a stimulus more map-like. These elements included: (1) correspondence with locations in geographic space, including elements such as perspective/view orientation, subject matter, correspondence with geographic reality, flatness of the object, geographic scale, (2) graphic nature of the stimulus, (3) symbolization, crafting, and controlled generalization (representing images that were predominantly symbolic), (4) prototype effect (correspondence with a Mercator map or a road map), and lastly, (5) use/function of a map.

2.4 Current Research

There are three primary goals of the current research. First, to determine what map type(s) serve as map prototypes for American college students. Secondly to examine potential changes of basic level categorization and classification of maps which may have resulted from increased public familiarity with technology driven imagery from satellites, digital elevation models, and the introduction of web mapping services.

Finally, this research will attempt to better define the role of individual map elements in developing the map prototype or the level of *mapness* inherent in a graphic. Variables to be investigated include perspective (verticality vs. obliqueness), the presence or absence of labeling, whether the graphic was drawn or recorded by cameras or satellite sensor,. In addition the research will investigate whether the role of subject matter specifically real vs. fantasy places, and rural vs. urban landscapes.

CHAPTER III

RESEARCH DESIGN

As maps are a system of communication between the cartographer and map percipients, it is important to note that the characteristics of both the instrument used to send the information and the characteristics of the audience for whom the information is intended are clearly intertwined in determining the features or functions that determine the degree to which an object is seen as a "map." As with previous studies (Vasiliev et al., 1990, Patton et al, 2005), this study utilizes an experimental approach to answer the question of what makes a graphic representation a map by showing visual stimuli to subjects for purposes of assessing elements of the representations that are map-like. Further, the stimuli were varied in content and perspective in order to identify elements of mapness. The current study increases the sample size over previous studies and contains more varied graphic representations to explore more fully if more recent representations are growing in influence as map like. In addition to investigating the role of individual elements necessary for an image to be seen as maplike, the study also looked at several widely used types (road maps, thematic, online maps, and reference maps), all of which contain all of the map elements Vasiliev et al. (1990) described as needed for the prototype.

3.1 Test Materials: Sets of Graphic Representations

To control for presentation bias, three sets of images were developed that were shown to novice map readers who were asked to rate each image on the basis of their goodness of fit with the concept of map.

A series of variables suggested by Vasiliev (1990) and Patton, et al (2004) were investigated. These were perspective or point of view (vertical, high oblique, low oblique) , whether or not the image was drawn or recorded (by camera or satellite sensor) the presence or absence of labeling, whether the location was rural or urban, whether the image was of an actual geographic region or was make believe or allegorical and finally was the image fundamentally a display of spatial arrangements. The following chart shows which of the elements were present or absent for each of the 26 types of images shown to the test subjects. Images ranged from those containing all of the characteristics that earlier research indicated was typical of a map to images which contained none of those elements (Table 3.1.1). The test images that contained none of the characteristics of a map are referred to as *foils.*

The statistical procedure, Cronbach's alpha, was used to determine the reliability of the three sets, or their ability to measure the same concepts. Each of the sets contained 26 different graphic representations, ranging from reference maps, road maps, and various thematic maps to graphs, charts, satellite imagery, and photographs (Figure 3.1.1, Figure 3.1.2 and Figure 3.1.3). Each set contained the same types of examples, but the individual objects varied from set to set in order to provide as complete a representation of all examples as possible.

Table 3.1.1 Map Type and Elements

Image Type	Spatial		Perspective			Labeling		Urban/ * Non Urban		Real/ Imaginary		Drawn/ Recorded			Map Type				
	Yes	No	Low Oblique	High Oblique	Vertical	No Labels	Labeled	Urban	Non Urban	Real	Imaginary	Drawn	Mix	Recorded	Road Map	Old Reference	New Reference	Thematic	On line
1. road map	●				●		●			●		●			●				
2. Online Street Map	●				●		●			●		●							●
3. Reference Map	●				●		●			●		●					●		
4. Old reference	●				●		●			●		●				●			
5. Satellite Vertical/ labels/urban	●				●		●	●		●			◐						
6. Allegorical	●				●		●				○	●							
7. High Oblique/ Photo/Labeled	●			◐			●	●		●			◐						
8. Birdseyeview/ drawn/labeled	●			◐			●			▒	▒	●							
9. Thematic Choropleth	●				●		●			●		●						●	
10. Thematic Isopleth	●				●		●			●		●						●	
11. Rough sketch of directions	●				●		●			●		●							
12. Thematic Prism	●			◐			●			●		●						●	
13. Thematic Grad. Symbol	●				●		●			●		●						●	
14. Air Photo/Vert. Urban/No labels	●				●	○		●		●				○					
15. Low Oblique Photo/labeled	●		○				●		○	●			◐						
16. Satellite-Verticlal no labels/urban	●				●	○		●		●				○					
17. Satellite/Vertical no labels non-urban	●				●	○		●		●				○					
18. Birdseyeview drawn/no labels	●			◐		○		▒	▒	▒	▒	●							
19. Organization Chart 2		○	▒	▒	▒		●	▒	▒			●							
20. Satellite Vertical/ no labels/rural	●				●	○			○	●				○					
21. Directions list	●																		
22. Organizational Chart		○	▒	▒	▒		●	▒	▒			●							
23. Low Oblique Photo/no labels	●		○			○			○	●				○					
24. Google Street View	●		○			○		○		○				○					
25. Foil		○	○			○				○				○					
26. Foil 2		○	○			○				○				○					

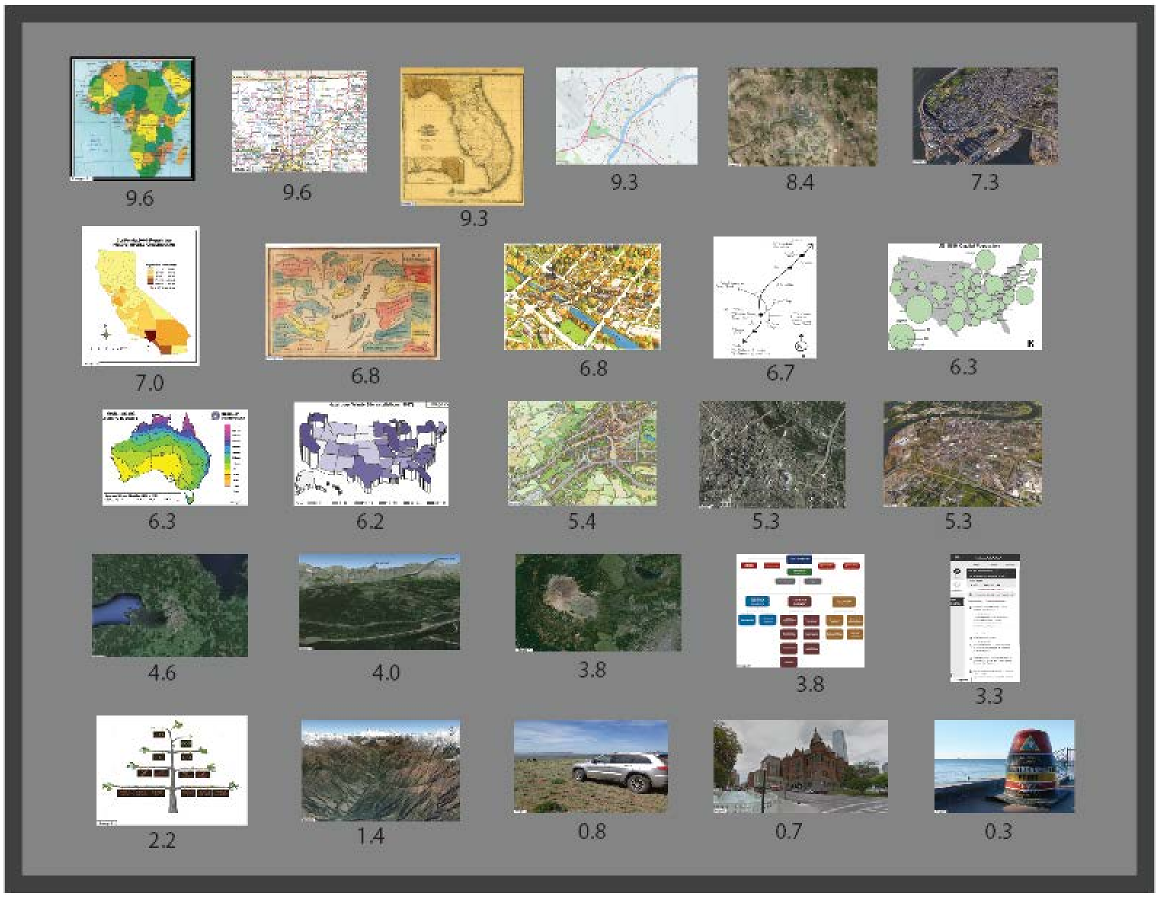
● FACTOR INCREASING "MAPNESS" ◐ NEUTRAL FACTOR ○ FACTOR DECREASING "MAPNESS" * Only relevant to Satellite or Air Photo Images

▒ UNKNOWN OR DOES NOT APPLY

The images were chosen to be examples of the following map characteristics: perspective, labeling, drawn versus recorded (satellite or photography), and fantasy versus real geographic space. Appendices A and B summarizes the maps and their characteristics. The sets included a full range of graphic representations that could be included in a superordinate category.

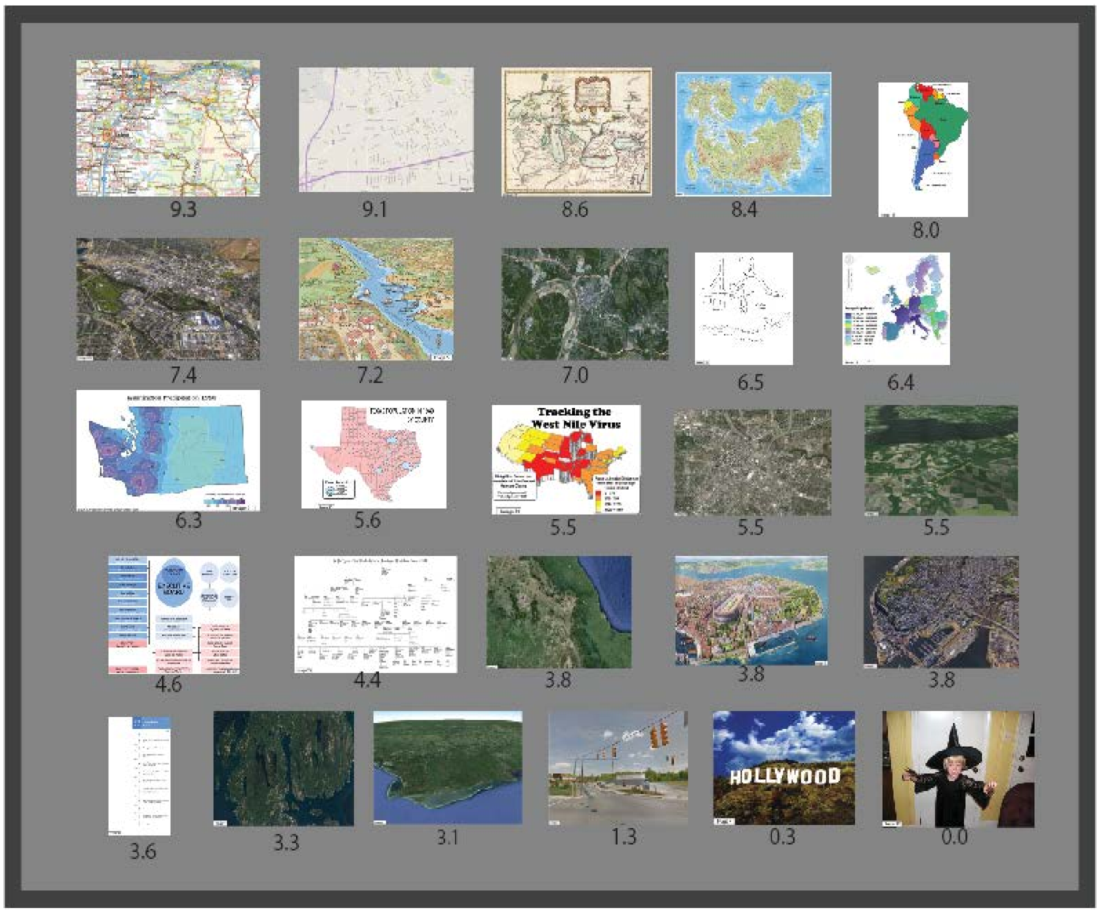
Figure 3.1.1 Set 1 – This Chart Shows the Rank Order of "Mapness" Generated By the Subjects for the Images of Set 1. The Number below Each Image is the Mean Value Given the Image on the "Mapness" Scale with 0 Indicating no Mapness and 10 Entirely Map.

Figure 3.1.2 Set 2 – This Chart Shows the Rank Order of "Mapness" Generated By the Subjects for the Images of Set 2. The Number below Each Image is the Mean Value Given the Image on the "Mapness" Scale with 0 Indicating no Mapness and 10 Entirely Map.



Each set was shown to the subjects in two different orders to control for any presentation effects, yielding Set 1a and 1b, Set 2a and 2b, and Set 3a and 3b. Information-rich bundles of perceptual and functional map characteristics were included in order to establish natural discontinuities or cliffs. Perceptual cliffs exist between different levels of the ranked objects and between members of the group.

Figure 3.1.3 Set 3 – This Chart Shows the Rank Order of "Mapness" Generated By the Subjects for the Images of Set 3. The Number below Each Image is the Mean Value Given the Image on the "Mapness" Scale with 0 Indicating no Mapness and 10 Entirely Map.



For that reason, foil images were provided for the test. Examples of foils showing no geographical characteristics included; a picture of a statue of a baseball player, a child dressed as a witch for Halloween, and the famous Hollywood sign. Bundled image characteristics included; satellite images with and without verticality of perspective (vertical, oblique, low oblique), Google, Bing, Yahoo, MapQuest, and Landsat satellite images with and without labels, street view maps from Google, and sketch images (hand drawn directional maps).

3.2 Subjects

As a cohort the subjects for the study, college students, have grown up in the "digital age" they have had exposure not only to traditional paper maps, but also to digital images found readily on the computer (e.g., Google maps, MapQuest). Subjects for the study were undergraduate, students drawn from six introductory earth science classes at the University of North Carolina Greensboro. Typically students enroll in this course in order to fulfill a university level general education requirement; as a result there is a wide range of majors represented. The only major normally not found in these courses is Geography as those students are advised to take a different course that contains a laboratory experience. This may be important as it may minimize the influence of classroom discussions on the nature of what is or is not a map.

Students from one class were asked to rate the pictures of set 1a, while students in another class were asked to rate the pictures of set 1b. The same procedure was followed for sets 2 and 3. In the end a total of 123 students rated set 1, 132 rated set 2, and 127 rated set 3, yielding a total of 382 subjects. Two hundred forty four of the subjects self identified as female and 129 as male. Nine identified as "not applicable or other." The data from 12 subjects was discarded due to what was considered to be "spoiled" responses (misunderstood the instructions, or intentionally ranked every image as a 10 or a 0).

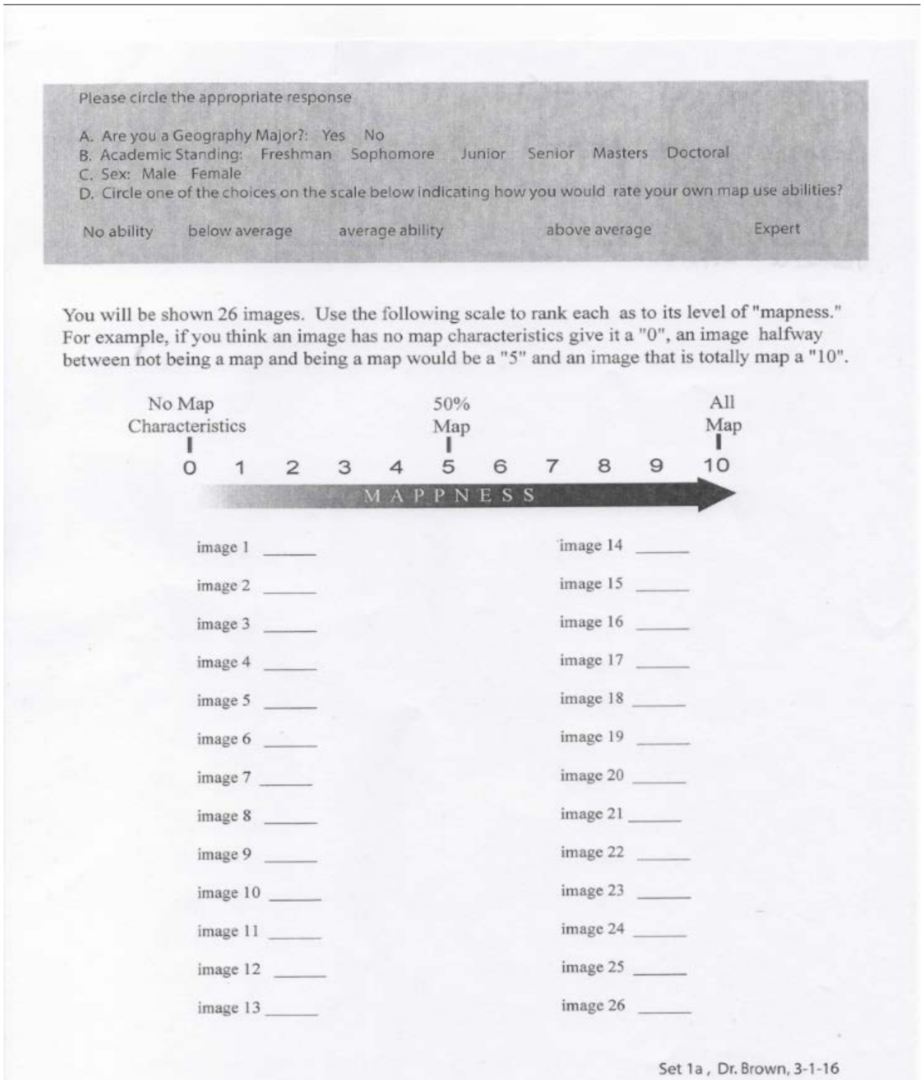
3.3 Experiment

On six separate occasions the experimenter entered the pre-arranged classrooms and quoted the following script:

> Good afternoon, my name is Ale and I am a graduate student here at UNCG. Dr. Brown has allowed me to use you all as "guinea pigs" for my research over the next 15 minutes. I will be showing you a series of images and asking you to rank how map like the images are. This is not a test, nor graded assignment, and there are no right or wrong answers. What I want you to do is to rank each image from 0 to 10 according to its degree of mapness.
>
> For example, if an image has no map qualities at all you rate the image as 0. If the image is entirely map you would give it a rating of 10. If the image is halfway between being a map and not map then it would get a rating of 5. You can use any number between 0 and 10 to rank how map like you believe the image is.
>
> Again, this is not a graded assignment, and there is no right or wrong answer. However I would greatly appreciate you doing this to the best of your ability as it is important for my research and my progress toward graduation. Thank you for helping me.

The form on which the students provided their responses (Figure 3.3.1) was passed out and explained. The test subjects were asked to complete a few questions about themselves – gender, academic standing, were they a geography major, and to rate themselves on map use ability. No other demographic information was requested so that responses could not be linked to a specific individual. Subjects were then presented, a series of 26 test images by projecting them, one at a time, onto a white screen found in the classroom. Each image was presented for 15 seconds during which time the student ranked the graphic representation along a continuum ranging from 0 indicating the image had no map-like qualities to 10 the image was entirely map. After the last image had been shown the record forms were collected. The whole test routinely took between 15 to 20 minutes to complete.

Figure 3.3.1 Form Used for Experiment



Please circle the appropriate response

A. Are you a Geography Major?: Yes No
B. Academic Standing: Freshman Sophomore Junior Senior Masters Doctoral
C. Sex: Male Female
D. Circle one of the choices on the scale below indicating how you would rate your own map use abilities?

No ability below average average ability above average Expert

You will be shown 26 images. Use the following scale to rank each as to its level of "mapness." For example, if you think an image has no map characteristics give it a "0", an image halfway between not being a map and being a map would be a "5" and an image that is totally map a "10".

No Map Characteristics 50% Map All Map

0 1 2 3 4 5 6 7 8 9 10

MAPPNESS

image 1 ______	image 14 ______
image 2 ______	image 15 ______
image 3 ______	image 16 ______
image 4 ______	image 17 ______
image 5 ______	image 18 ______
image 6 ______	image 19 ______
image 7 ______	image 20 ______
image 8 ______	image 21 ______
image 9 ______	image 22 ______
image 10 ______	image 23 ______
image 11 ______	image 24 ______
image 12 ______	image 25 ______
image 13 ______	image 26 ______

Set 1a , Dr. Brown, 3-1-16

3.4 Data Analysis and Preparation

An Excel spreadsheet was created to record the responses to each of the 3 sets of images shown to the test subjects. Each set contained 26 image types. 123 subjects viewed the images in set 1, 132 subjects viewed the images for set 2, and 127 subjects viewed the images in set 3. A total of 382 valid responses were recorded. Gender designation and self reported rating of map use abilities for each subject was also recorded. To assure that all three sets of images were measuring the same variables a Cronbach's alpha test was calculated. In the use of Cronbach's alpha test is a measure the reliability that the corresponding items in each of the sets are consistent. The strength of this consistency is measured on a scale of 0 to 1 with 1 representing the highest possible consistency. In other words the higher the alpha value the more the items have shared covariance indicating that the items measure the same underlying concept (University Virginia library). For the sets of images used in this study a value of 0.866 was found, indicating a very high level of reliability among the three sets of images. Thus it was safe to assume that the items found in three tests did in general measure the same functions and or elements. Mean averages, variances, and standard deviations, were calculated for the responses to each test image in each set of graphic representations. The next step was to combine the results of the three image sets and calculate the mean, variance, and standard deviation for each type of image shown. T-tests were performed to determine if significant gender differences existed to the responses.

The next step in the data analysis was the determination of the mean “mapness” score for each image in each set by averaging the scores given by the test subjects. A total score for each of the 26 image types was created by combining the responses found in each of the three sets of test images. The variance of scores given for each image was calculated to determine variability in the subject’s image scores.

A student’s test analysis (T-Test) was calculated to determine if the differences between the scores generated by male subjects was significantly different for the responses of female subjects.

The mean mapness values for the 26 images were then grouped utilizing the Jenks Optimal Classification methodology. This method was selected as it places those values that are most like one another in the same group while maximizing the difference between the groups -- like things together different things in different groups. The optimization classification scheme resulted in 8 distinct groups.

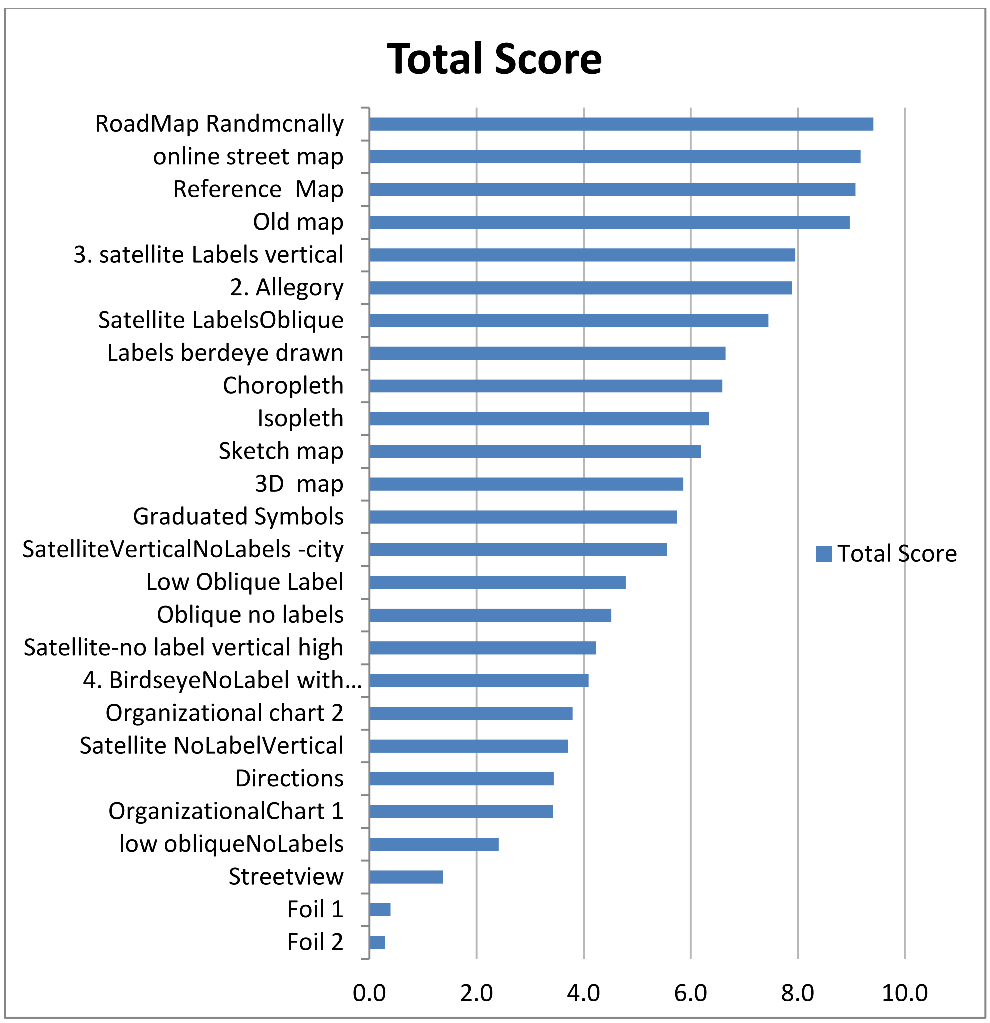
CHAPTER IV

FINDINGS

The critical first part of this study was to establish the reliability of the assessment tool, i.e., were the graphic images across sets 1, 2 and 3 equivalent and thus measuring the same variables. Since these map sets were to be used in a rating scale format and designed to measure the importance of underlying map characteristics, it was important to establish the reliability of the image choices to assure the validity of any analyses. Cronbach's Alpha, a numerical coefficient of reliability, calculated by measuring the reliability of a test relative to a second or third test using a different but related group of the same number of items was calculated for the results of the three sets of test images (Cronbach, L.J. 1951). The Cronbach's Alpha Coefficient obtained for the three sets was .87. This coefficient is considered to be quite high suggesting strong reliability and equivalency across the three sets.

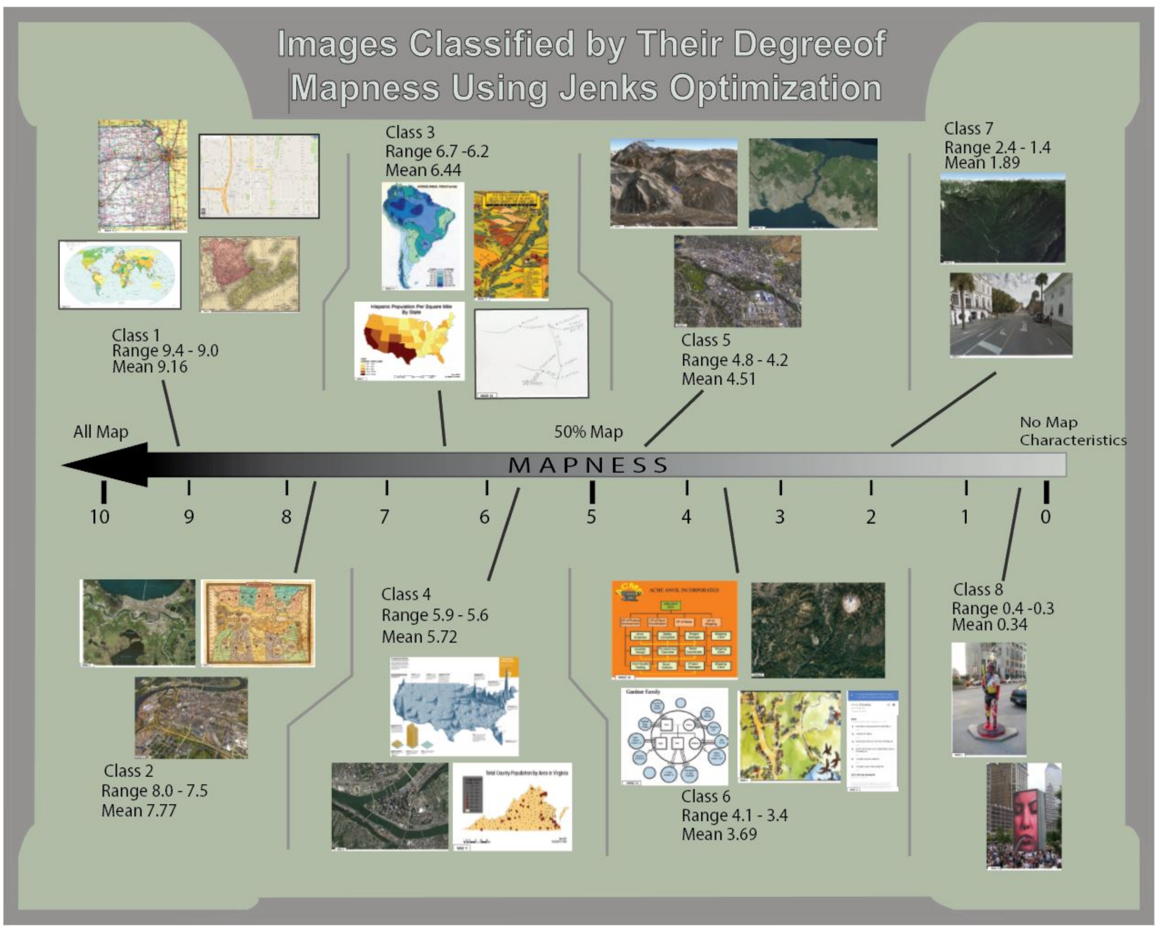
Each map types rating were averaged across all responses. Appendices C and D summarize the means and variances for each graphic representation. Review of the table indicates that the top four maps ranked by the combined subjects all contain the same characteristics. These characteristics include having a spatial nature, labeling, vertical perspective, real places, not recorded (not satellite images) and serve a navigational and reference functions. Also, the scores for the top four images had very low variance compared to all the other images (aside from the foil). The very high scores and very low variance in the scores are strong evidence that any of these images could serve as or at least very close to the prototype of a map. The responses to all of the other images, (with the exception of the foils) had a wider range of variance indicating less agreement among the subjects. The Foils, as expected, ranked lowest and had very little variability in the responses. Subjects uniformly saw no map like qualities in these images. The mean rating of each map-type is presented as a line graph in Figure 4.1.2.

Figure 4.0.1 Mean Averages of Sets 1, 2, and 3



A review of the histogram reveals natural breaks that were further explored by the Jenks Natural Break or Jenks Optimization statistical method. According to ESRI ArcMap, “natural breaks classes are based on natural groupings inherent in the data. Class breaks are identified that best group similar values and that maximize the differences between classes. The features are divided into classes whose boundaries are set where there are relatively big differences in the data values.” Eight classes were established and are discussed below (Figure 4.1.3).

Figure 4.0.2 Jenks Classification of Tested Images



As noted earlier, the maps used in this study fell into eight different classifications. The least map-like classification included the foils, which were not maps at all, but were random pictures selected for the study with no map characteristics. The use of foils establishes the lowest rating point and helps to control for subject rating error. If a foil is determined as most map-like then it is safe to assume that the subject did not understand the directions, or was attempting to spoil their responses. The mean rank for the category of foils was 0.34.

The next classification, Class 7, begins to contain some map-like features. This group contained images of street views provided by Google. The street views had limited labels. The group also contained low oblique images with no labels. The mean rank for this category was 1.89.

Class 6 contained the two organizational charts, handwritten directions and a vertical image of a rural area with no labels, and a bird’s eye view drawn map with no labels. The average ranking for the group was 3.69.

Class 5 contained low scale satellite images with vertical perspective and no labels, a satellite image with oblique perspective and no labels, and a low oblique satellite image with labels. This category had a mean ranking of 4.5.

Class 4 contained three images. The images were as follows; a vertical satellite image with no labels, but was an image of a city, a graduated symbols map, and a 3-D thematic map. The average ranking score for this class was 5.72.

The next category, class 3 had an average ranking of 6.44. Class 3 contained four images. This group included a sketch map, an isopleth map, choropleth map, and bird's eye drawn map with labels.

Class 2 contained three images. This group included satellite images with labels and oblique perspective, satellite images with labels and vertical perspective, and an allegorical map. The mean ranking for this category was 7.77.

Class 1, the most map-like, included four images. Images found in this category were an antique map, reference maps, online street maps, and the road-map Rand McNally, the number one rated map. The average rank for this category was 9.16.

Given the imbalance of gender, t-tests were performed to determine if there were any significant differences between map identification between male and female. The results appear in Table 4.1.1. Significant differences in ratings by gender existed for 6 images (using a two-tailed Student T Test, with a significance level of .1): Rand McNally road map, online street maps, reference maps, the old (antique) maps, allegory maps, and directional images.

Table 4.0.1 Male/Female Average Mean and t-test

	Foil 2	Foil 1	Street View	Satellite Low Oblique/No Labels	Organizational Chart 1	Satellite Vertical/No Labels	List of Directions	Organizational Chart 2	Birdseye View/No Labels with birds drawn	Satellite-no label vertical high	Satellite Oblique/No Labels	Satellite Low Oblique/Labels	Satellite Vertical/No Labels/Urban	Prism Thematic	Graduated Symbols	Isopleth Thematic	Sketch Map	Birdseye View/Labels drawn	Choropleth Thematic	Satellite Oblique/Labels	Satellite Vertical/Labels	Allegorical	Old Reference Map	Reference Map	Online Street Map	Road Map
Average fem	0.29	0.40	1.41	2.29	3.59	3.65	3.67	3.91	4.03	4.25	4.67	4.70	5.66	5.71	5.72	6.18	6.19	6.66	6.69	7.44	7.93	8.11	9.09	9.27	9.36	9.54
Average male	0.32	0.38	1.29	2.64	3.18	3.91	2.98	3.62	4.15	4.21	4.22	5.05	5.31	6.08	5.82	6.67	6.19	6.57	6.45	7.48	8.07	7.50	8.74	8.72	8.81	9.16
t-test	0.322	0.16795	0.585	1.335	1.108	0.829	2.052	0.802	0.387	0.138	1.429	1.224	1.167	1.219	0.341	1.546	0.013	0.338	0.78	0.153	0.623	2.113	1.935	2.846	3.262	2.445

Significant difference with a critical value of 1.649

Of these six images, five are the maps ranked as most map-like by the combined sample of male and female. The images were ranked as more map-like by females. The ranks did not change, only the degree of mapness (Figure 4.1.2). With regard to the gender differences on the six images where differences occurred, all of the images were related in that they all had navigational and referenced features.

A second test was conducted with 62 subjects from the previous study using a slightly different methodology. In this study each subject was given a set of paper images (if they had seen set 1 before, they were given either set 2 or set 3). Instead of placing a numeric mapness rating on each test image the subject was asked to layout the images in order on a large table from the least map like to the most. When the subject was satisfied with the order the test administrator recorded their rankings. The least map like was given 1 point the next 2 points and so on with the most map-like image receiving 26 points. The results from this study are displayed in Table 4.1.2. The highest ranking images were the same in this second test as they were in the main test. While there were a few movements in rank position for a few images in the second experiment compared to how they were ranked in the main test. When utilizing the optimal classification method the classes and members of each class remained the same regardless if they were evaluated using the method of the main test or the second test.

Figure 4.0.3 Male/Female Differences using t-test

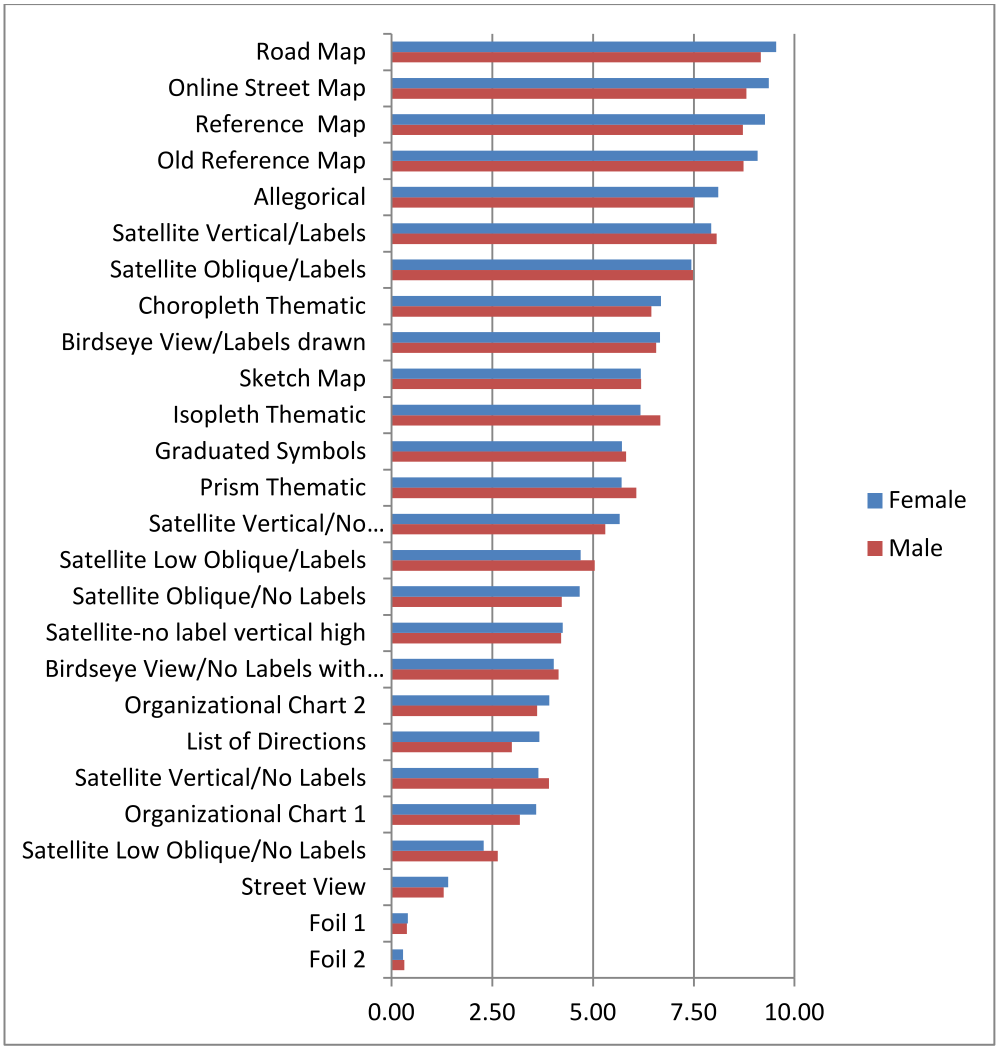
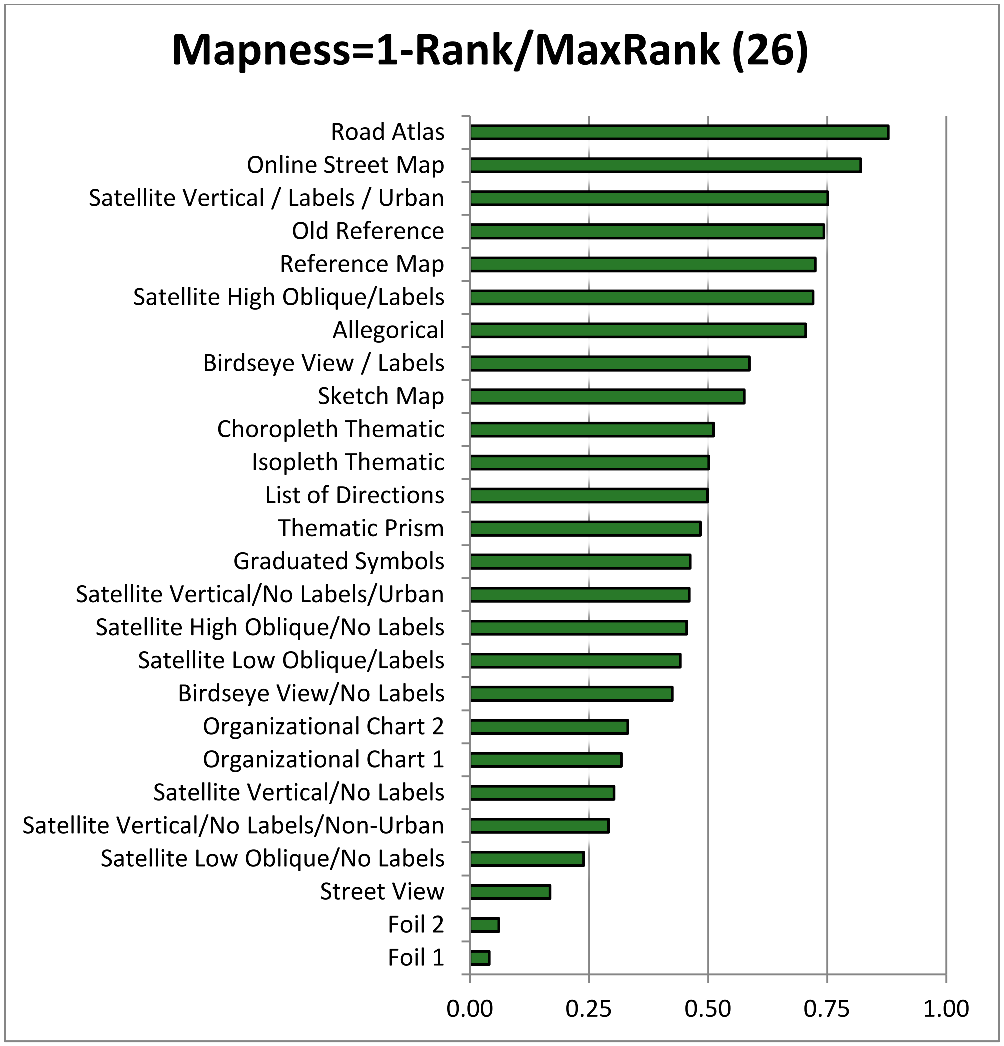


Figure 4.0.4 Ranked Images for Test 2



CHAPTER V

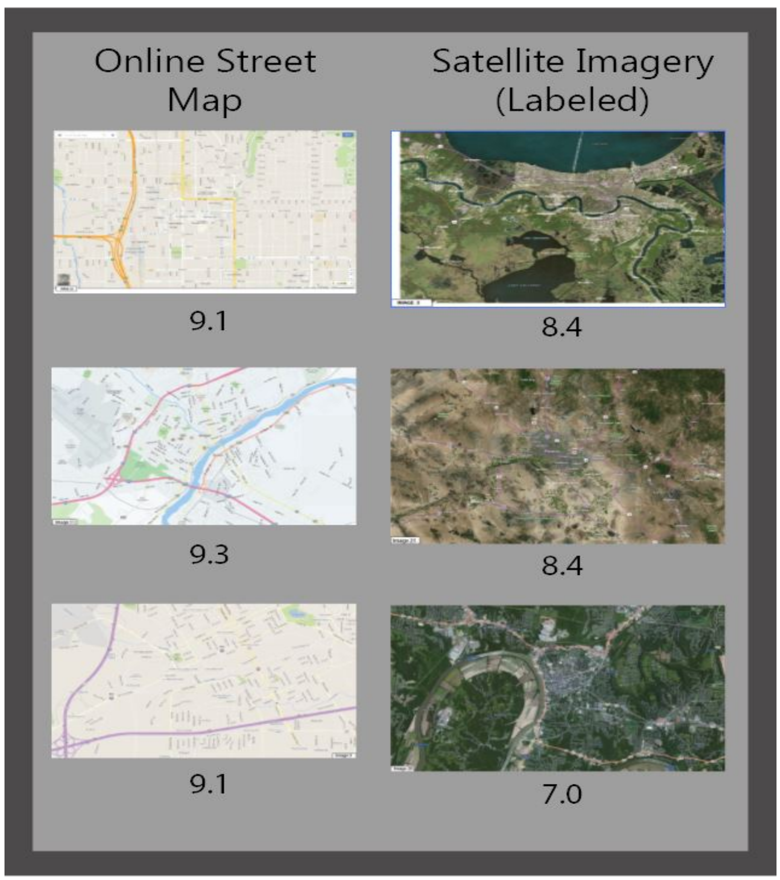
DISCUSSION

Prototype theory assumes the prototype has both functional and elemental characteristics. Current results suggest that for the map prototype two related functions are critical. First, the image must explain spatial relationships and second, the image must aid in navigation. With regard to necessary elements, representations that portrayed a geographic space or pseudo geographic space in the case of the fantasy images, had a vertical perspective, had labeling, showed an urban setting, were reality-based (a real location), and were drawn and photographed or recorded by satellite sensor all moved the graphic representation closer to the map prototype. Note that recorded images that contained a significant overlay of drawn material also increased the perceived map-like quality of the image. Lack of one or more of these elements did not preclude it from being a map, but did move the item away from the prototype.

Despite the use of subjects who have grown up in an age where satellite images are readily available, satellite images were not considered the most map-like in this study. Satellite imagery was ranked across 5 of 8 classes (excluding the top and bottom class in the Jenks Optimization Analysis). The ranking of these images along the continuum appeared to be more impacted by the other map elements included in the image (e.g., labeling, perspective, urban setting), than the recorded satellite image itself. One factor that may impact the lack of recognition of satellite images as map is the way in which

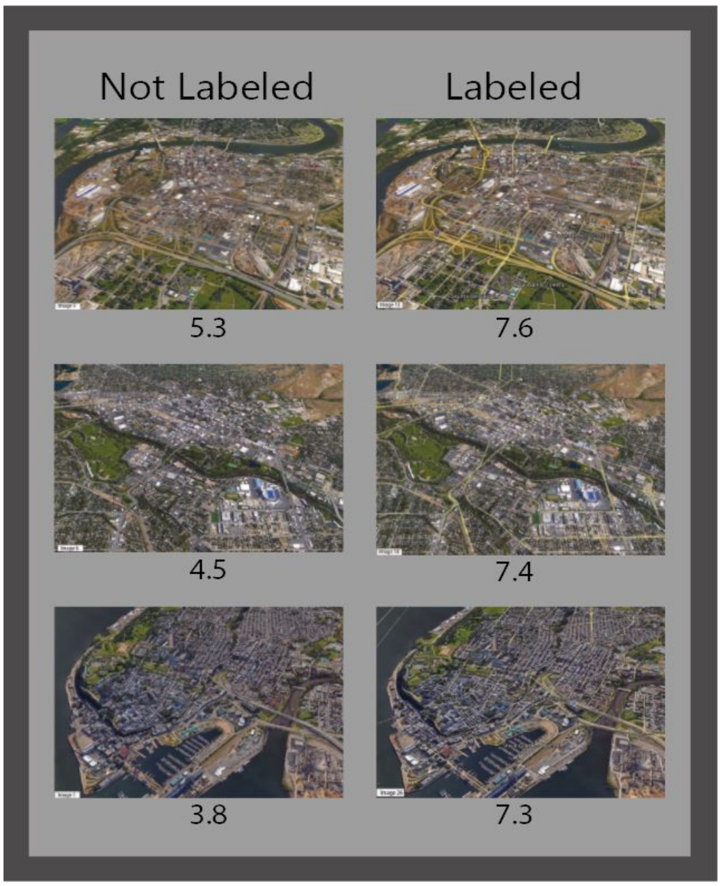
Internet sites such as Bing Maps and Yahoo Maps refer to recorded images on their sites as satellite views while drawn images are referred as the map view. These sites provide the option of displaying an area with or without a satellite image (or aerial photograph) as a backdrop. If one chooses to display the area with a satellite image it is no longer referred to as a map. Figure 5.0.1 shows the difference between online street maps and the satellite image option on the web mapping sites mention above.

Figure 5.0.1 Online Street Map vs. Satellite Image Mean Score



The evidence is clear that the lack of a spatial component precludes an image from being considered a map. Neither the charts nor the foils, which do not have a spatial component were seen as map-like at all. This supports the idea put forth by Robinson and Petchenik (1976) that maps fundamentally are spatial surrogates. These results also indicate that the presence of labels is a critical factor in the generation of map prototype. The presence of labels moves both drawn representation of place and satellite sensed images closer to the map prototype. Figure 5.0.2 shows the difference between high oblique images with labels and no labels.

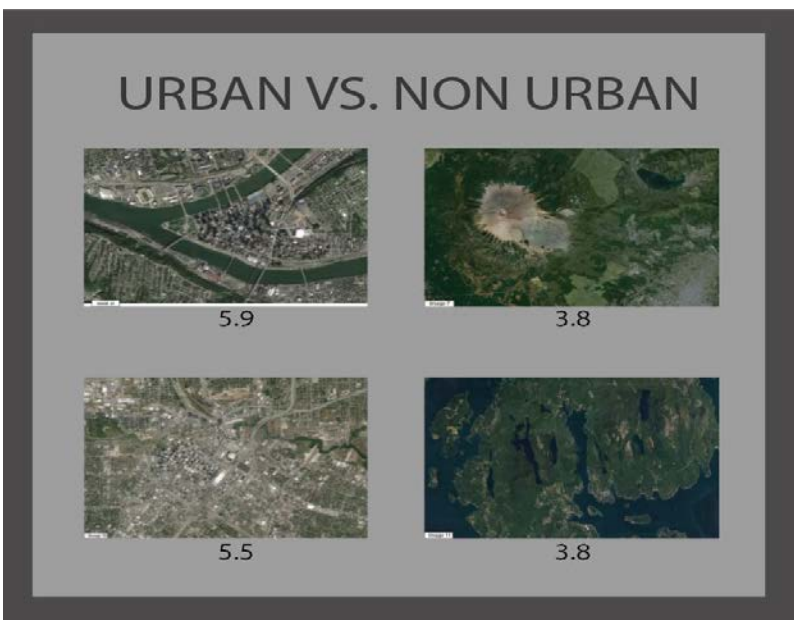
Figure 5.0.2 Labeled Images Scored Significantly Higher than a not Labeled Image



The labeled images mean average score was significantly higher than the same images with no labels. Street maps and satellite images (with labels) are both ranked high, however the “drawn” image is seen as nearer the prototype.

Perspective, such as obliqueness vs. verticality, does appear to be an important factor in determining map prototype as well. The vertical satellite images rated higher on average than oblique. Maps move “nearer” to the prototype when the graphic image represents a real world location. Further, it appears that an urban setting is more map-like than a rural setting (Figure 5.0.3). It is possible that the grid-like appearance of a city from above appears more map-like. Also, the city has more labels, making the image more map-like. In the case of satellite images without labels, urban settings ranked higher than rural settings.

Figure 5.0.3 Urban vs. Non Urban Differences



CHAPTER VI

CONCLUSION

Map readers create their own concepts of what a map is. However, it appears that there are essential elements and map functions that influence a percipients concept of *mapness*. Vasiliev et al. (1990) found that map elements such as labels and symbolization, the variation of perspective and scale, subject matter and place familiarity, and function all influence a person's assessment that a graphic representation fits the definition of a map. The results of this study appear to support their findings. The study also supports the prototype study by Patton et al. (2005) which suggested that road maps and general reference maps may serve as map prototypes. The current study found that in addition to the traditional road map and reference maps that on-line street maps may also be serving as map prototypes. The current research showed that satellite images had higher map-like ratings than those reported by Patton et al. This may be the result of the increasing familiarity students have with satellite and other recorded imagery than when the Patton et al study was undertaken. This would be consistent with the research in psychology on prototype theory that indicates that prototypes evolve over time. While thematic maps, such as choropleth, graduate symbol, prism and isopleth maps, contain all of the elements (spatial component, labeled, vertical perspective, drawn) thought to increase the map-like nature of the image all of them were rated significantly lower than the road, reference, or on-line street maps. This may be the result of thematic maps not being very useful for navigation or perhaps due to their having an additional function, that is of statistical data display, that the higher rated maps do not have. In any case further research into why thematic maps appear to be seen as less map like than non-thematic maps would be useful. Other areas for further research in map prototype include gender differences, and differences between experts in cartography and novices. Given the rise of online gaming, it would be interesting to determine the map level abilities in fantasy world gamers where location and point matters as much as it does in a real map. Future research could have an impact on understanding the technological level of the map prototype on GIS and GIS related analysis. Map prototypes are changing and one can speculate that new forms of mapping can change the prototype in the future.

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APPENDIX A

MAP DESCRIPTION USED IN STUDY PART 1

Map Type	**Description**
Road Atlas	Provides navigational information through road links.
On-line Street Map	Most commonly used map, computer-based map (e.g., Google maps).
Reference Map	Shows locations and political boundaries of countries and states.
Old Map	Copies of old maps from atlases.
Satellite Label Vertical	Street map based on satellite image.
Allegorical Map	Maps that include artistic images to reflect a story or theme.
Satellite Label Oblique	Satellite street map presented at an angle with no horizon.
Bird's Eye Drawn Map	Drawn map from a bird's view with labels.
Choropleth Map	Thematic map that shows discrete data through use of shade and color.
Isopleth Map	Thematic map for continuous data (e.g., temperature, rainfall).
Sketch Map	Hand drawn map showing direction from point A to point B.
3-D Map	Thematic map showing 3-D representation of data.
Graduated Symbols	Thematic map that shows information with a range of shapes indicating the amount of data measured.
Satellite Vertical-No Label City	Satellite image of a city.

APPENDIX B

MAP DESCRIPTION USED IN STUDY PART 2

Map Type	**Description**
Satellite Vertical-Low Scale	Lower scale satellite image.
Satellite Vertical-No Label Rural	Satellite image of a rural area.
Low Oblique with Label	Satellite image with labels at an angle with horizon shown.
Satellite Oblique no Label	Satellite image taken at an angle without labels and horizon.
Bird’s Eye no Label	A drawn image from bird’s eye view without labels.
Organizational Chart 1	Diagram that shows the structure of an organization or hierarchy.
Directional Image	Image that showed directions written.
Organizational Chart II	Diagram that shows the structure of an organization or hierarchy.
Satellite Low Oblique no Label	Satellite image of low obliqueness with no labels that shows horizon.
Street View	A technological feature of Google maps that provides a panoramic view along streets throughout the world
Foil I	Pictures that have no map features or characteristics.
Foil II	Pictures that have no map features or characteristics.

APPENDIX C

MEAN AND VARIANCE BY MAP TYPE PART 1

Map Type	**Mean**	**Variance**
Road Atlas	9.4	1.6
On-line Street Map	9.2	1.9
Reference Map	9.1	2.8
Old Map	9.0	2.5
Satellite Label Vertical	8.0	4.5
Allegorical Map	7.9	6.4
Satellite Label Oblique	7.5	5.4
Bird's Eye Drawn Map	6.7	6.4
Choropleth Map	6.6	8.2
Isopleth Map	6.3	8.6
Sketch Map	6.2	7.0
3-D Map	5.9	7.9
Graduated Symbols	5.7	8.9
Satellite Vertical-No Label City	5.6	8.0

APPENDIX D

MEAN AND VARIANCE BY MAP TYPE PART 2

Map Type	**Mean**	**Variance**
Satellite Vertical-Low Scale	4.8	6.9
Satellite Vertical-No Label Rural	4.5	8.3
Low Oblique with Label	4.2	8.3
Satellite Oblique no Label	4.1	7.9
Bird’s Eye no Label	3.8	11.3
Organizational Chart 1	3.7	8.4
Directional Image	3.4	10.4
Organizational Chart II	3.4	11.5
Satellite Low Oblique no Label	2.4	5.7
Street View	1.4	3.8
Foil I	0.4	1.0
Foil II	0.3	0.7