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The Utilization of Publicly Available Map Types by Non-Experts – A Choice Experiment

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Abstract. Assessing the fitness of *map types* for certain *task types* is a long-standing cartographic research challenge. One way to contribute to this research challenge is to study which map types people choose to use when they are given various tasks, thus documenting the current public preferences. While people’s choices may be expressions of bias to some degree, these may also be indications of appropriateness of these map types for the studied tasks. In this vein, we have conducted an online user study (n= 141, 74% male, 26% female) in which participants were given five map types to choose from while they executed 11 non-expert “everyday” map use tasks. In this paper, we report our findings on participant’s choices of map types associated with task types. Furthermore, we analyzed the map types in a categorized manner for 3D vs. non-3D, cartographic vs. photorealistic, and aerial perspective vs. first-person perspective and contrasted each with the task types.

Keywords: Map use, Map types, Task types, User Study

1. Introduction and Background

The type of representations we call “maps” continuously expand with the new technological and conceptual developments; thus, our efforts to understand when to recommend which map type are amplified (Fairbairn et al., 2001). Modern map providers offer the public various choices when it comes to map types. Which map type should we use when we are planning a route for our hike? How about when we are trying to get a feel for a destination we are about to travel? When we have cartographic maps, satellite imagery, street level imagery and photo-realistic 3D models; do we use them all, or mostly just one? If we chose a map type over the other, what does this tell? One (fairly common) approach to studying these questions is to categorize map types, and (map-use related) task types and “match them” (e.g., map type A is a good fit for task type B). Such undertaking is usually a complex one, as categories can be fluid.

In geography, the word *map* has been used flexibly to express abstract, diagram-like representations (schematic maps) such as the iconic London tube map (Cartwright, 2014) as well as very realistic and detailed representations such as virtual globes (Coltekin & Clarke, 2010). In this study, we broadly categorize map types based on *dimensionality* (3D vs. non-3D), *perspective* (aerial vs. first-person), and *level of realism* (cartographic vs. photo-realistic).

In terms of tasks, there has been considerable interest and efforts to create taxonomies (or typologies) in cartography, geographic visualization and related domains. We view these task typology efforts in two main categories; *high-level* (e.g., Carter, 2005; Shneiderman, 1996) and *low-level* (e.g., Amar & Stasko, 2004; Knapp, 1995; Wehrend & Lewis, 1990). High level typologies attempt capturing the goals of the user (e.g., “How to get to the airport” is a *route planning* task) while the low-level typologies seek to create classifications of the underlying cognitive processes to reach these goals (e.g., we need to first *find* our location and then the airport on the map; thus we need to conduct a *visual search* first). In this study, like in many others, we use high-level, thus “natural sounding”, tasks in the experiment.

User performance with maps can be different based on level of expertise – such that expert users may not be affected by design to the same degree as the non-expert users (e.g., Coltekin et al., 2010). In this study we focus on non-expert (public) users. In a previous study, we have shown six publicly available map types to 106 non-expert participants, and asked them to mark from a list of tasks (thus *report* based on what they believe/remember) whether they would use the shown map type for the listed tasks (Boér et al., 2013). In this paper, we present a follow-up study where our contribution is an early assessment of people’s map type *choices* when they execute actual map use tasks.

We believe our findings offer some new insights about map types and task types as well as a comparison between what people think they would use versus what they actually used. Furthermore, while the experiment has certain limitations, our observations and analysis lead to more informed hypotheses for future studies.

2. Experiment

The experiment was set up as a *choice experiment* in which we observed the map types participants selected for the tasks they were asked to execute. The study was conducted online for a better *ecological validity* (i.e. participants worked with the maps as they would normally do), and for maximizing number of participants.

2.1. Participants

Participants were recruited through email lists, personal and professional circles, as well as Amazon's Mechanical Turk service. [1] 245 participants submitted responses. However, we pre-processed the data and excluded the submissions with no values (missing data points), no time indications and/or if participants stated that they had diagnosed vision impairments. A total number of 141 international participants (74% male, 26% female) were retained the study, with an average age between 15-60 years old. 12% of the participants reported to have a high school degree, more than half (58%) a Bachelor's degree, 25% Master's, and 2% a Doctoral degree. Majority of the participants (88%) reported that they were familiar with geographic visualizations in varying degrees (32% slightly, 40% moderately, 14% very, 2% extremely familiar), while 12% reported they were "not at all familiar". Majority of the participants (roughly 90%) have never visited the cities that are included in the study (Los Angeles, Berlin, Paris, Prague, and Milan).

2.2. Materials

Stimuli We selected various commonly used map types to use in the experiment in different levels of realism/abstraction. Because Google products appear to be most commonly used; we decided to use their *Map View (2D)*, *Satellite View (2D)*, *Terrain View (2.5D)*, *Street View* (pseudo 3D) and *Earth View (3D)* (Figure 1).

Figure 1. Left to right: Examples of Google's Map, Satellite, Terrain, Street & Earth views

[1] https://www.mturk.com/mturk/welcome

Participants could choose one of the five map types to work with (examples shown in Figure 1). All maps were presented *interactively* in frames. The participant could choose a tab, and the maps loaded inside a frame (Figure 2).

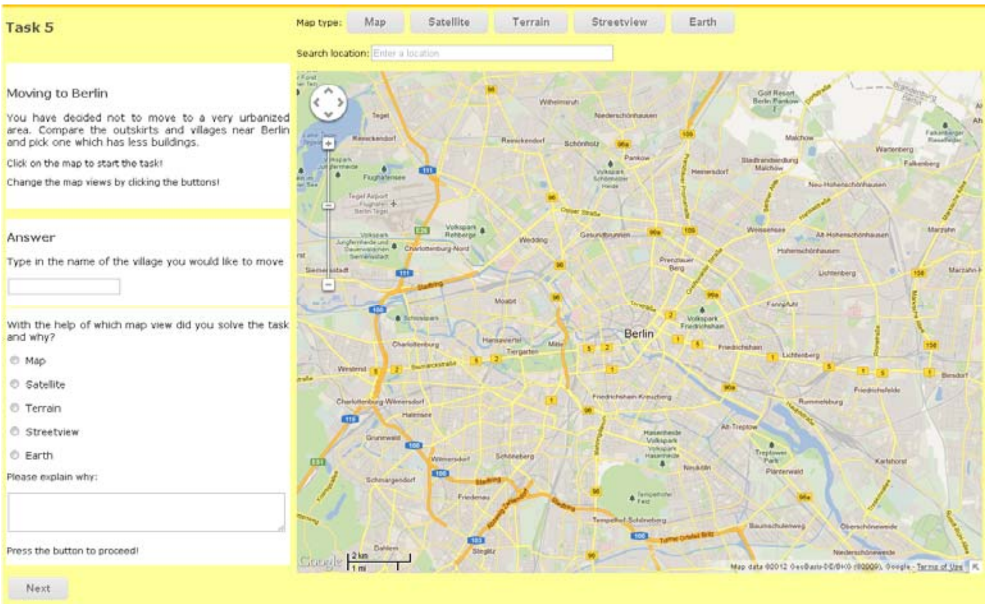

Figure 2. Survey interface showing an example task as executed by the participants (left pane) and the tabs where map type can be selected (top right).

Tasks 11 “non-expert” tasks were designed to correspond with five task categories for non-expert users. These five categories were developed based on Carter’s approach (2005) and our previous study (Boér et al., 2013): *self-location* (where am I), *route planning* (plan a drive), *identifying other locations* (find an address), *identifying places of interest* (place to rest, identifying sunny/shady spots), and *virtual tourism/planning* (explore the map, list things worth seeing), *virtual tourism/ sense of place* (what will your new neighborhood look or feel like). We divided virtual tourism to *planning* and in-situ *sense of place.* An example task, exactly as executed by the participants (and survey’s interface design) can be seen in Figure 2.

2.3. Measurements and analyses

To understand which views participants selected when executing the tasks, observations were extracted a) directly from the *self declared choices* of the participants at the end of every task and, b) inferred from an analysis of the *view activations* and *mouse clicks*. Taking advantage of the recorded *time* data; we extended the analysis by adding a comparison between the *view activations* (the percentage of participants who activated the particular views for the longest time period in every task) and the *self declared map choice*. This comparison provides a validation of whether the map type the participants used for solving the task coincides with the map type they had declared to have used. Another interesting comparison can be made among the *view activations* and the *click densities* (number and location of each click). With this comparison, one can extract information about which map types the participants "switched on" and finally, which map type was most used during the procedure. An accuracy analysis was also conducted to obtain an indication of whether the popular map types were also yielding good success rates.

At the analysis stage, we decided to group the participant's map choices not only based on basic map types (as listed in Figure 1), but also based on other fundamental criteria that is relevant in geographic visualizations. In this vein, we categorized the map types based on dimensionality (2D vs. 3D), abstraction-realism (cartographic vs. photo-realistic), and perspective (aerial perspective vs. first-person perspective) (Table 1).

Dimensionality	**3D**	Earth, Terrain, Street
	Non-3D	Map, Satellite
Realism level	**Photorealistic**	Satellite, Street, Earth
	Non-photorealistic	Map, Terrain
Perspective	**Aerial perspective**	Map, Satellite, Terrain
	First person perspective	Street, Earth

Table 1. Categorization of the map types

The study we present in this paper is very comprehensive; however, the experimental design has various limitations (further elaborated Results and Discussion section). Therefore, in this study we present all analysis in the form of descriptive statistics, which we believe gives interesting leads and clues for further (controlled) experiments despite the limitations.

3. Results and Discussion

3.1. Comparison of two surveys: *would use* vs. *used*

Our previous study (Boér et al., 2013) was a survey in which participants viewed several map types; and solely based on their own judgment or memories, marked if they thought they *would use* the shown map type for a number of listed tasks. They were allowed to mark more than one task (e.g., you could say I would use satellite images for *self-location* as well as *route planning*). In this study, we gave them typical non-expert geographic tasks; they worked on the tasks, and reported which map type they have solved the given task (see the lower part of the left pane in Figure 2). Figure 3 below shows a comparison of the two studies per map type and task type.

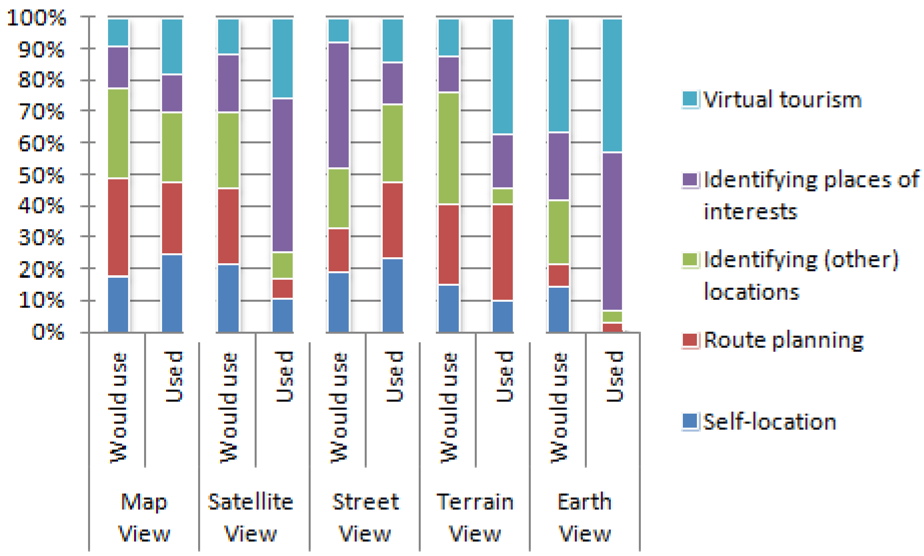

Figure 3. Columns labeled "would use" show participants' declaration of which map type they would use (hypothetical, as reported in Boér et al. 2013). Columns labeled "used" show which maps participants reported to have used *after* solving a task.

This comparison is interesting to understand better if people are good at "guessing" (even if it is based on experience) which map type they would use. Some previous studies suggested that there may be differences in people's preferences and performances, i.e., people may like animations or interactive displays, but it is possible that they make more mistakes with them in comparison to static displays (e.g., Hegarty et. al., 2009). In this particular case, what we show in

Figure 3 is not a performance measure, nonetheless, it shows the difference between what we think we would use, versus what we end up actually using when we solve a task. It is important to note that two studies were independent online studies, i.e., these results are from two different populations, thus may have some hidden *sampling bias*. Furthermore, the first study ("would use") was a straightforward question where the second one ("used") has *our judgment*; as we needed to decide a representative question for each task type. Last but not least, in the second study (the one we report in here), the results may be suffering from an *order bias* as the order of the tabs was not randomized, i.e., 2D was always first, which may have increased its use (see Figure 2). The fact that Earth View was always last may have lowered its usage (furthermore, participants were asked to download a plug-in for Earth View).

Despite these limitations, we believe Figure 3 provides some food for thought. These results indicate a number of obvious mismatches between what people thought they *would* use, versus what they reported to have used when they were given a "real" task (a scenario); most evident in Earth View, and least in Map View. For the Map View, the results seem roughly similar, thus we interpret that participants have a good understanding for what they utilize 2D maps. For the Satellite View, we see a large discrepancy as they thought they would use it similarly to a 2D cartographic map (Map), but in fact they use Satellite View considerably more for identifying points of interest and somewhat more for virtual tourism but not as much for locating oneself (or other things) and route planning. Their estimations for Street View were also not a good match with their choices when they actually executed a task. They imagined they would use Street View more for identifying places of interest, but in fact they have a fairly balanced use of it for almost all tasks, least of which is "identifying places of interest". The largest mismatch is in the Earth View. While people estimated that they would, in some cases, use Earth View for locating themselves, there were *zero* cases of this when they were asked to do so. This also shows in route planning and identifying other locations; more than 90% of the time Earth View is used for virtual tourism or identifying places of interest.

3.2. View activations

At this point, we compared the view activations with the self-declared choices. Figure 4 shows the results of this comparison.

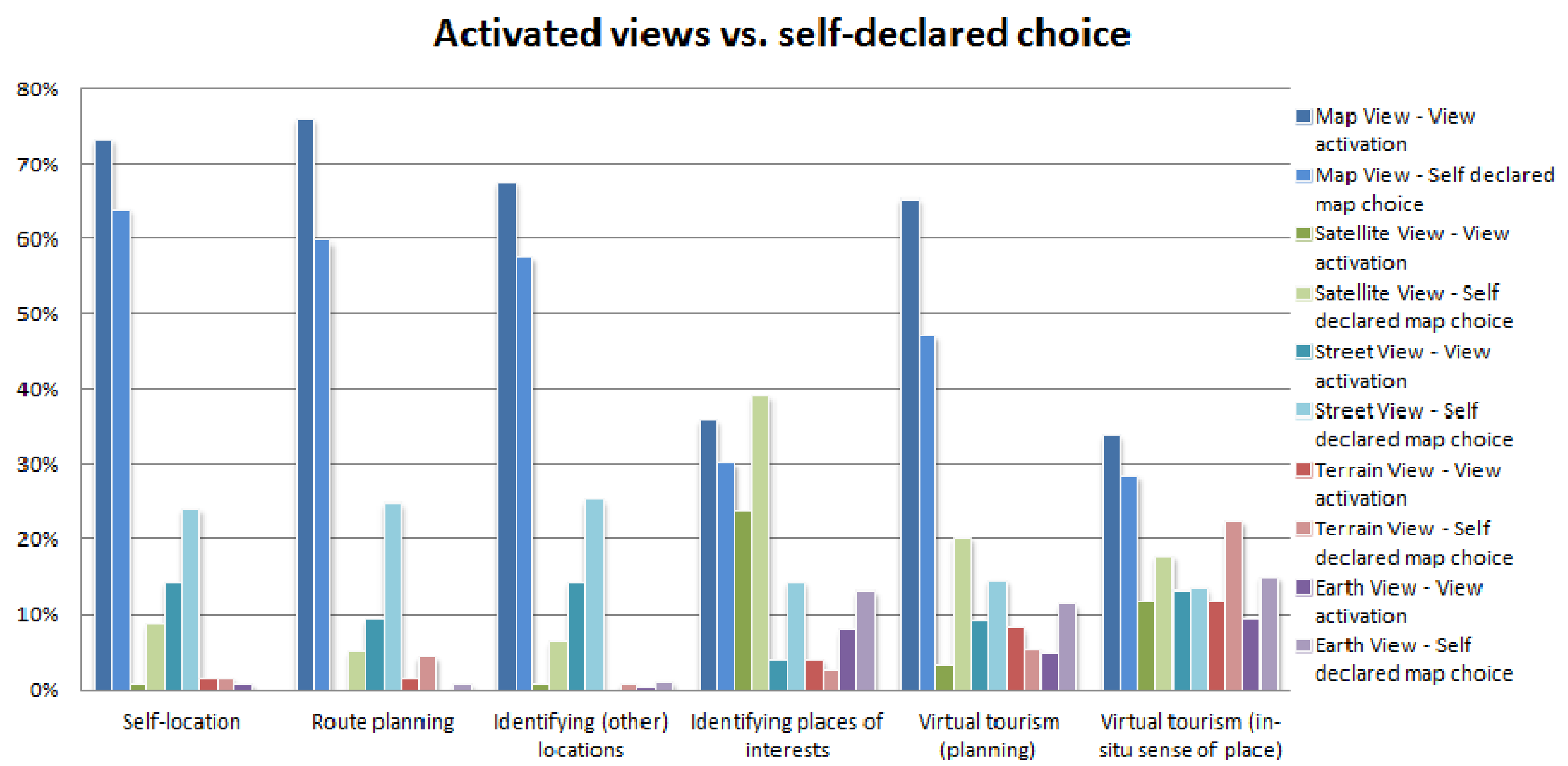

Figure 4. Percentages of self declared map choices vs. view activations for each task.

This comparison (Figure 4) is interesting, because it may tell us if people spent time looking at various map types but decided to use another one. We would expect to see a rough agreement between the self-declared map type used for the task, and the view activations (the percentage of participants who activated the particular views for the longest time period in every task). A strong disagreement creates further questions as to whether people may have tried solving the task with another view but eventually gave up; or if they may have used information from one map type but eventually complete the task with another one. This comparison, as in the previous one, should be viewed as preliminary indications for hypothesis building, rather than leading to absolute conclusions. The results largely confirm that the map types participants declared to have selected are indeed the ones that were activated most. An interesting point may be that the view activations appear to have higher percentages than the self-declared ones on the Map View, regardless of the task type. However, we believe this can be explained by the previously mentioned order effect (i.e., Map View was listed first).

3.2. Classification of visualizations

3D vs. non-3D Extending our analysis, we categorized visualizations not only based on map type, but also based on other common criteria as explained earlier (see Table 1). Below we provide a summary of this analysis. Figures 5 and 6 illustrate our observations for 2D views vs. 3D views.

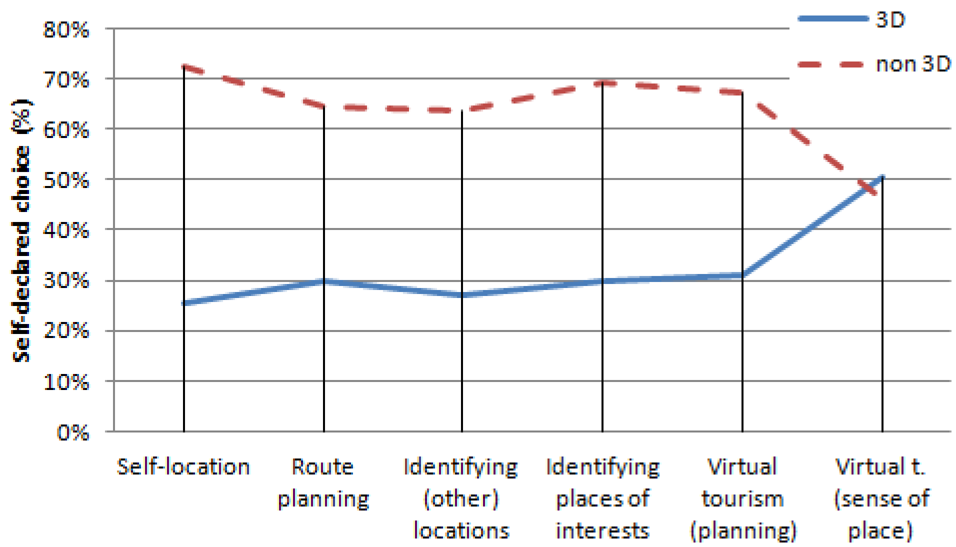

Figure 5. Participants' choices categorized for dimensionality.

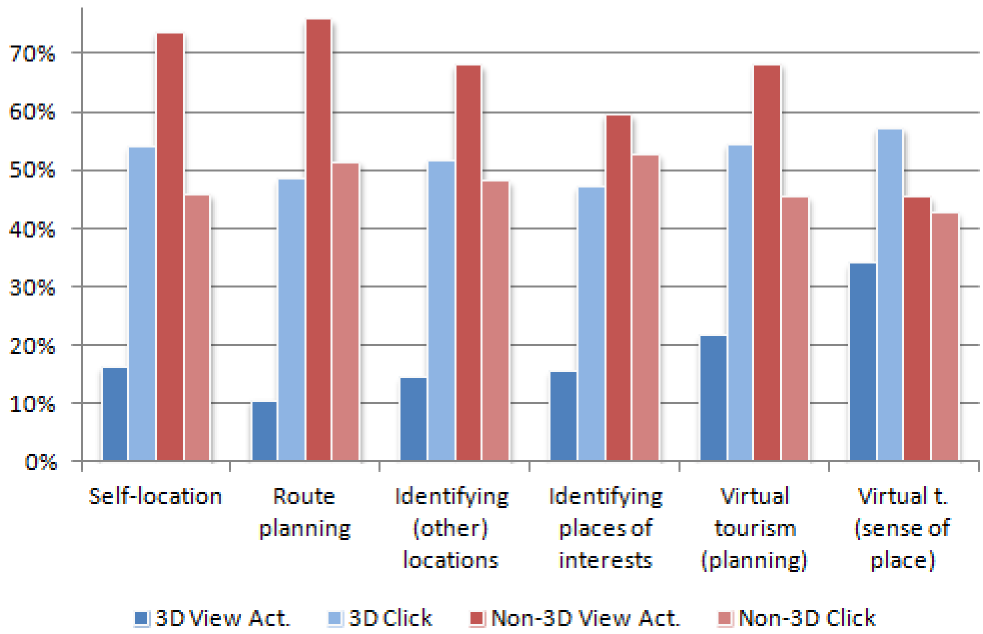

Figure 6. Comparing the proportion of view activations vs. mouse clicks for dimensionality.

Figure 5 clearly demonstrates that for most tasks (roughly 70%), non-3D visualizations are used. An exception for this appears to be the particular tasks that involved getting a sense of place through virtual tourism. For this task type, 3D representations are used equally; or in fact slightly more than non-3D representations. This is particularly interesting to note as the 3D visualizations were listed "later" in the order, meaning that for some tasks 3D views were essential. Figure 6, on the other hand, shows another interesting difference between 3D and non-3D Views. According to these results, we see that fewer participants activate the 3D views for the longest duration but they interact (mouse clicks) with them proportionally more. In other words, if we divide the mouse clicks with view activations, we would observe the opposite trends for 3D and non-3D views. This might be an indication that we need more interactivity in 3D views, possibly to avoid the well-known occlusion issues (Duchowski & Coltekin, 2007; Elmqvist & Tsigas, 2007). Furthermore, we have previously observed that 3D can introduce perceptual issues (Bernabé & Coltekin, 2014), and with complex visualizations, people tend to use the mouse even when it is not needed (Coltekin et al., 2014).

Photorealistic vs. non-photorealistic Another interesting categorization that is relevant in geographic visualization research is the level of abstraction/realism. To explore whether the map types showed any patterns based on realism levels, we re-categorized them. Figure 7 shows the participants' self-declared choices plotted against task types for this category.

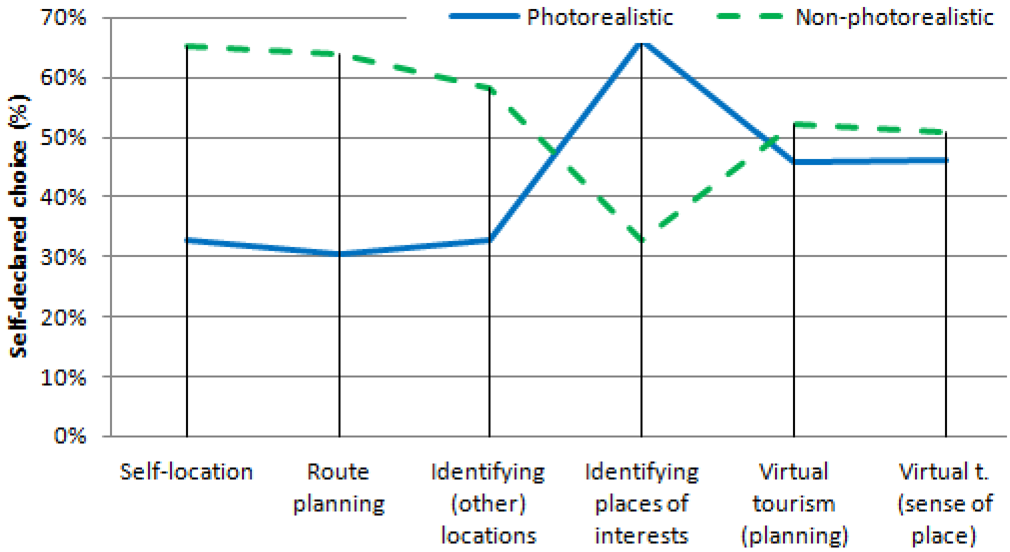

Figure 7. Participants' choices categorized for realism levels.

The results presented in Figure 7 suggest also an interesting pattern. While for most tasks people use non-photorealistic representations more; for *identifying places of interest*, photo-realism appears to be more relevant. This observation needs to be further tested in controlled studies; nonetheless, even in its current form, it allows us to hypothesize that realistic displays may be best used in global feature recognition tasks. Current literature has mixed evidence in terms of usability and usefulness of imagery; however based on these results we believe further research to study them in relation to task types is well-justified. Similarly as in 3D vs. non-3D, Figure 8 shows a difference in the view activations for photorealistic representations versus the proportional mouse clicks, and similar speculations can be made. Images are more complex visualizations, and while the mouse clicks may indicate activity towards solving the task, it may also indicate possible difficulty with the display.

Aerial vs. first-person perspective Being able to transform our perspective (literally as well as figuratively) is a hard task. Users of cartographic products are often expected to mentally transform (rotate, orient) what is in their view to another space (e.g., match a

2D map depicted from an *aerial perspective* to real environment which is *first-person perspective*).

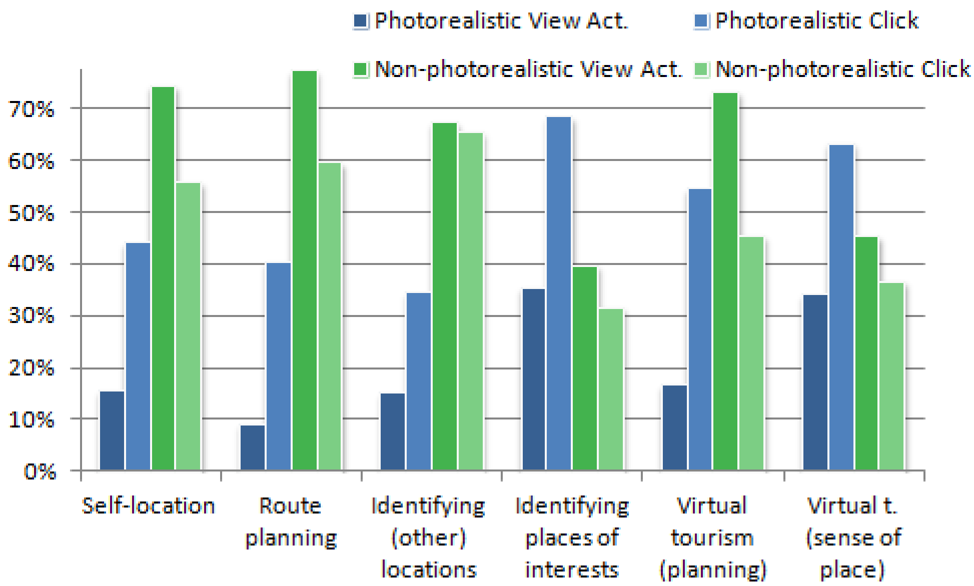

Figure 8. Comparing the proportion of view activations vs. mouse clicks for realism levels.

Understanding for which tasks we find the aerial perspective useful, and for which the first person perspective useful allows us to better understand how to combine the use of the two, or when to utilize one or the other. We categorized aerial views versus first-person perspective and observed that participants use aerial perspective consistently more (roughly 70% of the time) for all task types, without exceptions (Figure 9). This is interesting as it appears to be different than 3D – in the case of 3D views (Earth, Terrain, Street); terrain view is considered 3D even if it is not first-person view. In the classification we used here, first person perspective is exclusively the Street View and Earth View. The fact that this categorization changes the results considerably is a good reminder of how important it is that we are transparent and diligent about what we call 3D and that there are various ways of thinking about these views. Figure 10 also tells a different story than in the case of 3D vs. non-3D, as the aerial views have similar rates of view activations and mouse clicks. However, the pattern that there is a higher proportion of mouse clicks with the “more complex view” remains true for first-person views, possibly because there are more occlusions in these views.

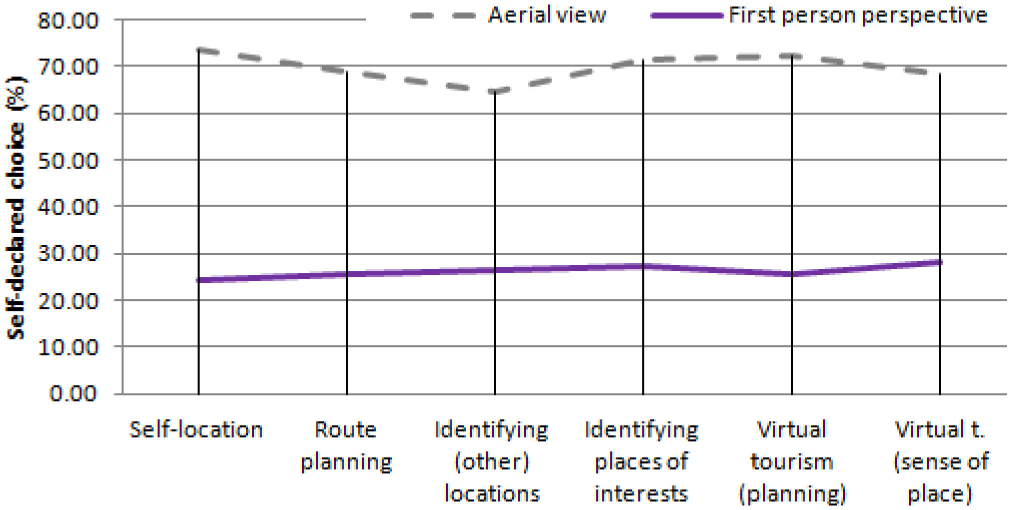

Figure 9. Participants' choices categorized for perspective.

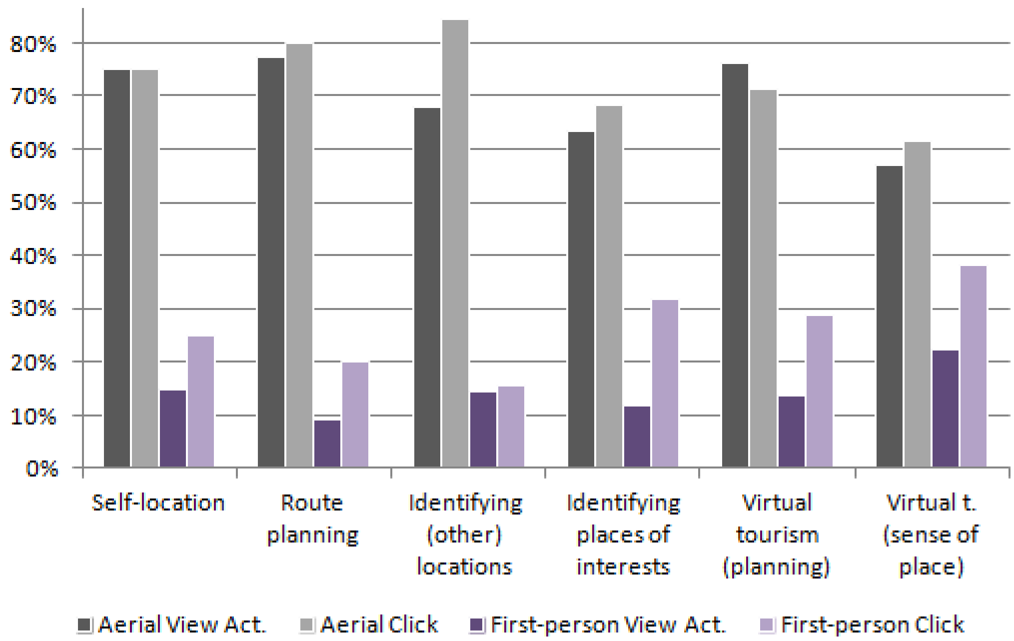

Figure 10. Comparing the proportion of view activations vs. mouse clicks for perspective.

Accuracy Last but not least, an accuracy analysis showed that overall people were most effective (i.e., gave the largest number of correct responses) with the Map View, followed by Street, Satellite, Earth and Terrain Views. Map View yielded some success in all tasks, but dominantly so for route planning, identifying self or other locations.

Street View appears to facilitate route planning (where one can identify landmarks) most, Satellite View leads the identifying places of interest and appears to have more incorrect responses than correct responses for identifying other locations. Earth View has most "correct" answers for virtual tourism tasks, though arguably, these are hard tasks to quantify. Terrain View appears to be similar for virtual tourism, however doing poorer than the Earth View in other tasks.

4. Conclusions

In this paper we presented a comprehensive study in which we analyzed people's map-type choices for various non-expert tasks and compared them with a number of measures based on descriptive statistics. Overall, with this study we documented that more complex forms of visualizations may be most appropriate for only fairly specific use cases. While the study has its limitations, our findings confirm previous understanding of map types in relation to task types and various measurements validate each other. Therefore, we believe our findings contribute to cartography and geovisualization research as indicative observations that justify further research on these topics through controlled studies.

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