International Cartographic Association
Association Cartographique Internationale

Take That Flood+: Does your perspective matter?

Fabian Kuster [a], Ian T. Ruginski [b], and Sara Irina Fabrikant [b*]

[a] *Independent Scholar, fabian.kuster@hispeed.ch*[1]
[b] *Department of Geography and Digital Society Initiative, University of Zurich, {ian.ruginski,sara.fabrikant}@geo.uzh.ch*

* Corresponding author

Keywords: Flood hazard mapping, risk perception, display perspective, empirical study, decision outcomes

Abstract:

The growing frequency of significant flood events as one of the effects of global climate change, highlights the increased importance of using appropriate communication methods to inform the general public about the risks to human life and to the environment (Hagemeier-Klose & Wagner, 2009). To raise public flood risk awareness, authorities typically produce 2D flood hazard maps. In the U.K., however, only 45% of the population living in flood risk areas are indeed aware of this hazard, for instance (Rollason et al. 2018). Perhaps current 2D flood hazard maps have limited impact in raising public risk awareness because the target audience may have difficulty in interpreting abstract, static, 2D displays of a dynamic volumetric process (Haynes et al., 2007)? Current research is still undecided on whether static, abstract 2D or more realistic, interactive 3D visualizations should be used to communicate environmental hazards or risk (Macchione et al. 2019, Leskens et al., 2017). We aim to move a step closer towards closing this research gap, by empirically studying how the display perspective of static flood maps might influence human risk perception, thus purposefully excluding interactivity, and any other 3D visualization options. More specifically, we set out to firstly empirically assess human risk perception of static, orthographic perspective (2D) and oblique perspective (2.5D) flood maps (between-subject), and secondly, how individual risk attitudes might influence risk perception of the visualized floods. Using two viewing perspectives, Figure 1 depicts a set of test map stimuli of an identical flood event in Virginia Beach, USA, inspired by the U.S. Federal Emergency Management Agency (FEMA) Flood Risk Products[2].

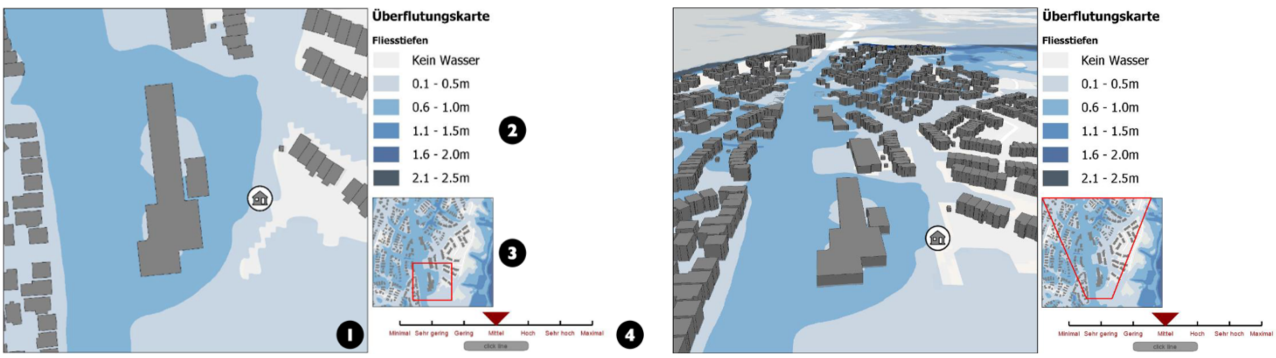

Figure 1. (a) orthographic 2D flood map stimulus (b) perspective 2.5D flood map stimulus

Map stimuli were developed with ArcGIS Pro 2.3.0 and ESRI's Flood Impact Analysis package 1.0, using flood depth data obtained from FEMA's flood risk database[3]. The building footprints were downloaded from the City of Virginia Beach's Open GIS Data Portal (2019). Except for the viewing perspective (a:1), the information content was kept identical across the randomly ordered trials in each display condition. The stimuli contained a smaller scale inset map (a:3), classed flood depths levels (meters) in blue, from lighter blue for shallower flood levels to darker blue showing deeper flood levels (a: 1&2). An interactive slider (a:4) allowed participants to indicate their risk assessments on a Likert-style scale ranging from "minimum" (=1) to "maximum" (=7) risk with respect to a house location marker shown in the map.

Thirty-four people (f=14, m=16; 16-47 yrs.; avg.= 26.2 yrs.) participated in person during the COVID-19 pandemic, following safety regulations issued by Swiss authorities. Participants provided University of Zurich ethical-board approved informed consent prior to completing the task. We removed two people who only took part in the pilot experiment, and two more needed to be excluded from data analysis, because their German language skills were insufficient for the task. The experiment took place at a quiet location in participants' homes, in and around Lucerne,

[1] This research was carried out at the University of Zurich as a Master's thesis by the first author, supervised by the co-authors.
[2] https://arcg.is/vjjf5, accessed 2021
[3] https://msc.fema.gov/portal/advanceSearch, accessed 2021
[+] https://www.youtube.com/watch?v=aCHg5r6rFoI, accessed 2021

https://doi.org/10.5194/ica-abs-3-167-2021

Switzerland, running PsychoPy on an ASUS ZenBook UX430UN-GV060T laptop equipped with a 14” color display, set to 1920x1080 pixel resolution.

After filling in a background questionnaire, participants completed a modified version of the Balloon Analogue Risk Task (BART) to assess their risk behavior (Lejuez, 2002). This task involves inflating digital balloons with different maximal inflation points using a virtual pump. Each pump action earns participants virtual money until the balloon reaches its maximal inflation point when it will explode, and all earned money is lost. Participants can decide to stop the game at any time and keep collected money if the balloon does not pop. They were not told that their risk attitude was measured for this task, and they could take as much time as they needed. Following that, participants were randomly assigned to either the 2D or 2.5D condition to complete 16 map trials (plus 2 practice trials), asked to rate the risk of building their home at a given house marker location (Figure 1, a:1).

We hypothesized that participants would perceive flood risks shown on 2D maps to be smaller compared to those shown in 2.5D (Macchione et al., 2019), and that participants would take less time for their risk assessments for the 2.5D maps, because of the lower cognitive load and the lesser need for interpretation compared to the more abstract 2D maps (Leskens et al., 2017).

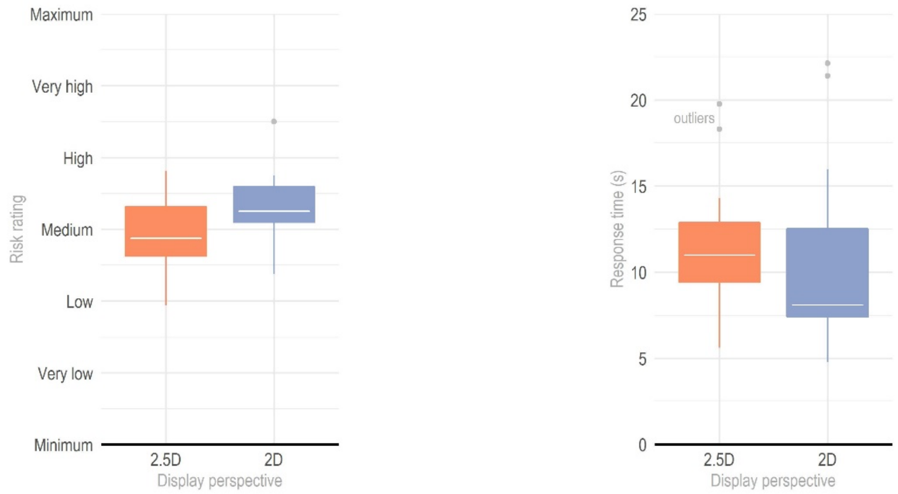

Figure 2 (a) Average 2D group risk rating is higher than the 2.5D group. (b) Average 2D group response time is faster than the 2.5D group.

[the median is depicted with a white line]

Our collected data (Figure 2) suggests little credible evidence to support any of above stated hypotheses. The non-parametric Wilcoxon-Mann-Whitney test ($Z= 1.87$, $p > .05$) does not yield significant results for participants’ averaged (non-normally distributed) risk ratings across display conditions (2a). A linear mixed effect analysis on task completion time (2b), also reveals no significant differences ($p > .05$) in response time between experimental groups, even when controlling for the influence the individual factors of risk attitudes (BART) and map use experience. In the sense of parsimony, we might interpret this to mean that the common 2D perspective will serve its purpose equally well to the oblique perspective, with the assumption, of course, that the 2D maps need to be well designed.

We included three post-test think-aloud trials in our study to get further qualitative insights on what kinds of strategies participants might have applied to solve the test task. This analysis reveals interesting future research avenues: Firstly, houses at the border of different flood depth classes were mentioned more often in the 2D group compared to the 2.5D group. Inferences about the relief and water flow direction was equally considered across map conditions. The inset map was consulted more often in the 2.5D group compared to the 2D group.

Our empirical evidence on how viewing perspective might influence measured risk perception is in line with prior inconclusive research on the utility and usability of adding a third viewing dimension (Lieske et al., 2014). Still, the think-aloud analysis turned out to be very useful to verify that participants understood the task correctly. Lieske et al. (2014) suggest that additional cognitive effort to imagine the real world in a 2D and 2.5D abstraction may lead to misunderstandings of the displayed information. In this sense, the think-aloud portion of the test ensured that only data from participants who had understood the task correctly were examined in our statistical analysis.

With additional empirical evidence on how static 2D and oblique 2.5D hazard maps might influence the public’s risk perception and decision making, we hope to further inform policy and decision makers on the critical importance of well-designed cartographic displays for effective and efficient hazard and risk communication. We also provide an open-source code repository for making reproducible experiments with our static maps (https://osf.io/meznc/).

[References are added on a third page for completeness]

https://doi.org/10.5194/ica-abs-3-167-2021

References:

Hagemeier-Klose, M., & Wagner, K. (2009). Hagemeier-Klose, M. and Wagner, K.: Evaluation of flood hazard maps in print and web mapping services as information tools in flood risk communication, Nat. Hazards Earth Syst. Sci., 9, 563–574, https://doi.org/10.5194/nhess-9-563-2009, 2009.

Haynes, P., Hehl-Lange, S., & Lange, E. (2018). Mobile Augmented Reality for Flood Visualisation. Environmental Modelling and Software, 109, 380–389. https://doi.org/10.1016/j.envsoft.2018.05.012.

Leskens, J. G., Kehl, C., Tutenel, T., Kol, T., Haan, G. de, Stelling, G., & Eisemann, E. (2017). An interactive simulation and visualization tool for flood analysis usable for practitioners. Mitigation and Adaptation Strategies for Global Change, 22(2), 307–324. https://doi.org/10.1007/s11027-015-9651-2.

Lieske, D. J., Wade, T., & Roness, L. A. (2014). Climate change awareness and strategies for communicating the risk of coastal flooding: A Canadian Maritime case example. Estuarine, Coastal and Shelf Science, 140, 83–94. https://doi.org/10.1016/j.ecss.2013.04.017 Macchione, F., Costabile, P., Costanzo, C., & De Santis, R. (2019). Moving to 3-D flood hazard maps for enhancing risk communication. Environmental Modelling and Software, 111, 510–522. https://doi.org/10.1016/j.envsoft.2018.11.005.

Rollason, E., Bracken, L. J., Hardy, R. J., & Large, A. R. G. (2018). Rethinking flood risk communication. Natural Hazards, 92(3), 1665–1686. https://doi.org/10.1007/s11069-018-3273-4.

https://doi.org/10.5194/ica-abs-3-167-2021