

## A full list of the 87 studies included in the review

- Alam, S. S., & Jianu, R. (2017). Analyzing Eye-Tracking Information in Visualization and Data Space: From Where on the Screen to What on the Screen [Article]. *IEEE Transactions on Visualization and Computer Graphics*, 23(5), 1492-1505. <https://doi.org/10.1109/tvcg.2016.2535340>
- Almahmoud, J., Albeaik, S., Alrashed, T., & Almalki, A. (2017). Visual exploration patterns in information visualizations: Insights from eye tracking. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics),
- Anagnostopoulos, V., Havlena, M., Kiefer, P., Giannopoulos, I., Schindler, K., & Raubal, M. (2017). Gaze-Informed location-based services [Article]. *International Journal of Geographical Information Science*, 31(9), 1770-1797. <https://doi.org/10.1080/13658816.2017.1334896>
- Bartling, M., Resch, B., Eitzinger, A., & Zurita-Arthos, L. (2019). A multi-national human-computer interaction evaluation of the public participatory GIS GeoCitizen [Article]. *GI Forum*, 7(1), 18-39. [https://doi.org/10.1553/GISCIENCE2019\\_01\\_S19](https://doi.org/10.1553/GISCIENCE2019_01_S19)
- Bartling, M., Resch, B., Trösterer, S., & Eitzinger, A. (2021). Evaluating PPGIS Usability in a Multi-National Field Study Combining Qualitative Surveys and Eye-Tracking [Article]. *Cartographic Journal*, 58(2), 167-182. <https://doi.org/10.1080/00087041.2020.1842143>
- Bekele, M. K. (2019). Walkable Mixed Reality Map as interaction interface for Virtual Heritage [Article]. *Digital Applications in Archaeology and Cultural Heritage*, 15, Article e00127. <https://doi.org/10.1016/j.daach.2019.e00127>
- Bertel, S., Dressel, T., Kohlberg, T., & Von Jan, V. (2017). Spatial knowledge acquired from pedestrian urban navigation systems. Proceedings of the 19th International Conference on Human-Computer Interaction with Mobile Devices and Services, MobileHCI 2017,
- Bianconi, F., Filippucci, M., Cornacchini, F., & Seccaroni, M. (2022). IMMERSIVE VISUAL EXPERIENCE FOR WAYFINDING ANALYSIS. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives,
- Blascheck, T., John, M., Koch, S., Bruder, L., & Ertl, T. (2016). Triangulating user behavior using eye movement, interaction, and think aloud data. Eye Tracking Research and Applications Symposium (ETRA),
- Blascheck, T., John, M., Kurzahls, K., Koch, S., & Ertl, T. (2016). VA2: A Visual Analytics Approach for // Evaluating Visual Analytics Applications [Article]. *IEEE Transactions on Visualization and Computer Graphics*, 22(1), 61-70, Article 7192649. <https://doi.org/10.1109/TVCG.2015.2467871>
- Bogucka, E. P., & Jahnke, M. (2018). Feasibility of the space-time cube in temporal cultural landscape visualization [Article]. *ISPRS International Journal of Geo-Information*, 7(6), Article 209. <https://doi.org/10.3390/ijgi7060209>
- Brady, D., Ferguson, N., & Adams, M. (2018). Usability of MyFireWatch for non-expert users measured by eyetracking [Article]. *Australian Journal of Emergency Management*, 33(4), 28-34.
- Brock, A. M., Truillet, P., Oriola, B., Picard, D., & Jouffrais, C. (2015). Interactivity Improves Usability of Geographic Maps for Visually Impaired People. *Human-Computer Interaction*, 30(2), 156-194. <https://doi.org/10.1080/07370024.2014.924412>
- Buddeberg, J., Jenny, B., & Willett, W. (2017). Interactive shearing for terrain visualization: an expert study. *GeoInformatica*, 21(3), 643-665. <https://doi.org/10.1007/s10707-016-0283-9>
- Burch, M. (2018). Visual analysis of eye movement data with fixation distance plots. Smart Innovation, Systems and Technologies,
- Burch, M. (2019). *Interaction graphs: visual analysis of eye movement data from interactive stimuli* Proceedings of the 11th ACM Symposium on Eye Tracking Research & Applications, Denver, Colorado. <https://doi.org/10.1145/3317960.3321617>
- Burch, M., Wallner, G., Broeks, N., Piree, L., Boonstra, N., Vlaswinkel, P.,... Van Wijk, V. (2021). The Power of Linked Eye Movement Data Visualizations. Eye Tracking Research and Applications Symposium (ETRA),
- Coltekin, A., Garlandini, S., Heil, B., & Fabrikant, S. (2008). Evaluating the Effectiveness of Interactive Map Interface Designs: A Case Study with Eye Movement Analysis. <https://doi.org/10.5167/uzh-10125>
- Coltekin, A., Hempel, J., Brychtova, A., Giannopoulos, I., Stellmach, S., & Dachsel, R. (2016, Jul 12-19). GAZE AND FEET AS ADDITIONAL INPUT MODALITIES FOR INTERACTING WITH GEOSPATIAL INTERFACES. *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences* [Xxiii isprs congress, commission ii]. 23rd ISPRS Congress, Prague, CZECH REPUBLIC.
- Cybulski, P., & Horbinski, T. (2020). User Experience in Using Graphical User Interfaces of Web Maps [Article]. *ISPRS International Journal of Geo-Information*, 9(7), 14, Article 412. <https://doi.org/10.3390/ijgi9070412>
- De Cock, L., Ooms, K., Van de Weghe, N., & De Maeyer, P. (2020, 2020//). Google Indoor Maps or Google Indoor No Maps? Usability Study of an Adapted Mobile Indoor Wayfinding Aid. HCI International 2020 - Posters, Cham.
- De Cock, L., Van de Weghe, N., Ooms, K., Saenen, I., Van Kets, N., Van Wallendael, G.,...De Maeyer, P. (2022). Linking the cognitive load induced by route instruction types and building configuration during indoor route guidance, a usability study in VR [Article]. *International Journal of Geographical Information Science*, 36(10), 1978-2008. <https://doi.org/10.1080/13658816.2022.2032080>
- Dedkova, P., & Popelka, S. (2015). Virtual 3D restoration of an extinct village and its eye-tracking assessment [Article]. *Journal of Mobile Multimedia*, 11(3-4), 181-192.

- Demšar, U., & Çöltekin, A. (2017). Quantifying gaze and mouse interactions on spatial visual interfaces with a new movement analytics methodology [Article]. *PLOS ONE*, 12(8), Article e0181818. <https://doi.org/10.1371/journal.pone.0181818>
- Deng, Z., Chen, Y., Yu, Q., Xu, Z., & Ye, X. (2023). An Experimental Study on Web Interface Design Optimization Based on User Cognitive Load. *Frontiers in Artificial Intelligence and Applications*,
- Dobesova, Z. (2020). Evaluation of effective cognition for the QGIS processing modeler [Article]. *Applied Sciences (Switzerland)*, 10(4), Article 1446. <https://doi.org/10.3390/app10041446>
- Dong, W., Ran, J., & Wang, J. (2012). Effectiveness and Efficiency of Map Symbols for Dynamic Geographic Information Visualization. *Cartography and Geographic Information Science*, 39(2), 98-106. <https://doi.org/10.1559/1523040639298>
- Dong, W., Wang, S., Chen, Y., & Meng, L. (2018). Using eye tracking to evaluate the usability of flow maps [Article]. *ISPRS International Journal of Geo-Information*, 7(7), Article 281. <https://doi.org/10.3390/ijgi7070281>
- Fairbairn, D., & Hepburn, J. (2023). Eye-tracking in map use, map user and map usability research: what are we looking for? [Article]. *International Journal of Cartography*, 9(2), 231-254. <https://doi.org/10.1080/23729333.2023.2189064>
- Giannopoulos, I., Kiefer, P., & Raubal, M. (2015). Gaze nav: Gaze-based pedestrian navigation. *MobileHCI 2015 - Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services*,
- Göbel, F., Giannopoulos, I., & Raubal, M. (2016). The importance of visual attention for adaptive interfaces. *Proceedings of the 18th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct, MobileHCI 2016*,
- Göbel, F., & Kiefer, P. (2019, Jun 25-28). POITrack: Improving Map-Based Planning with Implicit POI Tracking. [Etra 2019: 2019 acm symposium on eye tracking research & applications]. 11th ACM Symposium On Eye Tracking Research and Applications (ETRA), Denver, CO.
- Göbel, F., Kiefer, P., & Raubal, M. (2019). FeaturEyeTrack: automatic matching of eye tracking data with map features on interactive maps [Article]. *GeoInformatica*, 23(4), 663-687. <https://doi.org/10.1007/s10707-019-00344-3>
- Golebiowska, I., Opach, T., & Rod, J. K. (2020). Breaking the Eyes: How Do Users Get Started with a Coordinated and Multiple View Geovisualization Tool? [Article]. *Cartographic Journal*, 57(3), 235-248. <https://doi.org/10.1080/00087041.2019.1660513>
- Golebiowska, I., Opach, T., & Rød, J. K. (2017). For your eyes only? Evaluating a coordinated and multiple views tool with a map, a parallel coordinated plot and a table using an eye-tracking approach [Article]. *International Journal of Geographical Information Science*, 31(2), 237-252. <https://doi.org/10.1080/13658816.2016.1191636>
- Herman, L., Popelka, S., & Hejlová, V. (2017). Eye-tracking Analysis of Interactive 3D Geovisualization. *Journal of Eye Movement Research*, 10. <https://doi.org/10.16910/jemr.10.3.2>
- Horbinski, T., Cybulski, P., & Medynska-Gulij, B. (2020). Graphic Design and Button Placement for Mobile Map Applications [Article]. *Cartographic Journal*, 57(3), 196-208. <https://doi.org/10.1080/00087041.2019.1631008>
- Hsiao, S. W., Peng, P. H., & Tsao, Y. C. (2021). A method for the analysis of the interaction between users and objects in 3D navigational space [Article]. *Advanced Engineering Informatics*, 50, Article 101364. <https://doi.org/10.1016/j.aei.2021.101364>
- Chen, X., & Jin, R. (2017). Statistical modeling for visualization evaluation through data fusion [Article]. *Applied Ergonomics*, 65, 551-561. <https://doi.org/10.1016/j.apergo.2016.12.016>
- Choi, T. H., Ji, S. Y., Hong, Y. Y., & Jun, H. J. (2024, Apr 20-26). WEB-BASED 3D HEATMAP VISUALIZATION OF SPATIAL COGNITION USING EEG AND EYE TRACKING DATA. *International Conference on Computer-Aided Architectural Design Research in Asia* [Proceedings of the 29th international conference of the association for computer-aided architectural design research in asia, caadria 2024, vol 3]. 29th International Conference of the Association-for-Computer-Aided-Architectural-Design-Research-in-Asia (CAADRIA), Singapore, SINGAPORE.
- Juřík, V., Herman, L., Kubíček, P., Stachon, Z., & Šašínska, Č. (2016). COGNITIVE ASPECTS OF COLLABORATION IN 3D VIRTUAL ENVIRONMENTS. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLI-B2*, 663-670. <https://doi.org/10.5194/isprs-archives-XLI-B2-663-2016>
- Keskin, M., & Kettunen, P. (2023). Potential of eye-tracking for interactive geovisual exploration aided by machine learning [Article]. *International Journal of Cartography*, 9(2), 150-172. <https://doi.org/10.1080/23729333.2022.2150379>
- Kiefer, P., Giannopoulos, I., & Raubal, M. (2013). Using eye movements to recognize activities on cartographic maps. *GIS: Proceedings of the ACM International Symposium on Advances in Geographic Information Systems*,
- Kiefer, P., Giannopoulos, I., Raubal, M., & Duchowski, A. (2017). Eye tracking for spatial research: Cognition, computation, challenges [Review]. *Spatial Cognition and Computation*, 17(1-2), 1-19. <https://doi.org/10.1080/13875868.2016.1254634>
- Krassanakis, V., & Cybulski, P. (2019). A review on eye movement analysis in map reading process: the status of the last decade [Review]. *Geodesy and Cartography*, 68(1), 191-209. <https://doi.org/10.24425/gac.2019.126088>
- Kudelka, V., Dobesova, Z., & Sgem. (2015, Jun 18-24). EYE-TRACKING TESTING OF GIS INTERFACES. *International Multidisciplinary Scientific GeoConference-SGEM* [Informatics, geoinformatics and remote sensing, vol i (sgem 2015)]. 15th International Multidisciplinary Scientific Geoconference (SGEM), Albena, BULGARIA.
- Kwok, T. C. K., Kiefer, P., Schinazi, V. R., Adams, B., Raubal, M., & Assoc Comp, M. (2019, May 04-09). Gaze-Guided Narratives: Adapting Audio Guide Content to Gaze in Virtual and Real Environments. [Chi 2019: proceedings of the 2019 chi conference on human factors in computing systems]. CHI Conference on Human Factors in Computing Systems (CHI), Glasgow, SCOTLAND.
- Li, J., Meng, Z.-P., Huang, M.-L., & Zhang, K. (2017). An interactive visualization approach to the overview of geoscience data. *Journal of Visualization*, 20(3), 433-451. <https://doi.org/10.1007/s12650-016-0352-z>

- Li, J., Meng, Z. P., Huang, M. L., & Zhang, K. (2015, Aug 24-26). An Interactive Radial Visualization of Geoscience Observation Data. [8th international symposium on visual information communication and interaction (vinci 2015)]. 8th International Symposium on Visual Information Communication and Interaction (VINCI), Tokyo, JAPAN.
- Liao, H., Dong, W., Peng, C., & Liu, H. (2017). Exploring differences of visual attention in pedestrian navigation when using 2D maps and 3D geo-browsers [Article]. *Cartography and Geographic Information Science*, 44(6), 474-490. <https://doi.org/10.1080/15230406.2016.1174886>
- Liao, H., Zhang, C., Zhao, W., & Dong, W. (2022). Toward Gaze-Based Map Interactions: Determining the Dwell Time and Buffer Size for the Gaze-Based Selection of Map Features [Article]. *ISPRS International Journal of Geo-Information*, 11(2), Article 127. <https://doi.org/10.3390/ijgi11020127>
- Manson, S., Kne, L., Dyke, K., Shannon, J., & Eria, S. (2013). Using Eye-tracking and Mouse Metrics to Test Usability of Web Mapping Navigation. *Cartography and Geographic Information Science*, 39, 48-60. <https://doi.org/10.1559/1523040639148>
- May, J., Gamble, T., & Acm. (2014, Apr 26-May 01). Collocating Interface Objects: Zooming into Maps. [32nd annual acm conference on human factors in computing systems (chi 2014)]. 32nd Annual ACM Conference on Human Factors in Computing Systems (CHI), Toronto, CANADA.
- Mendonça, A., & Delazari, L. (2014). Testing Subjective Preference and Map Use Performance: Use of Web Maps for Decision Making in the Public Health Sector. *Cartographica: The International Journal for Geographic Information and Geovisualization*, 49, 114-126. <https://doi.org/10.3138/carto.49.2.1455>
- Mendonça, A. L. A., & Delazari, L. S. (2012). Remote Evaluation of the Execution of Spatial Analysis Tasks with Interactive Web Maps: A Functional and Quantitative Approach. *Cartographic Journal The*, 49, 7-20. <https://doi.org/10.1179/1743277411Y.0000000020>
- Napiersalski, P. E., Altenhoff, B. M., Bertrand, J. W., Long, L. O., Babu, S. V., Pagano, C. C., & Davis, T. A. (2014). An evaluation of immersive viewing on spatial knowledge acquisition in spherical panoramic environments [Article]. *Virtual Reality*, 18(3), 189-201. <https://doi.org/10.1007/s10055-014-0245-1>
- Nisiforou, E. A., Michailidou, E., & Laghos, A. (2014). Using eye tracking to understand the impact of cognitive abilities on search tasks. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics),
- Nivala, A.-M., Brewster, S., & Sarjakoski, L. (2008). Usability Evaluation of Web Mapping Sites. *The Cartographic Journal*, 45. <https://doi.org/10.1179/174327708X305120>
- Ooms, K., De Maeyer, P., & Fack, V. (2010). *Analyzing eye movement patterns to improve map design* (Vol. 38).
- Ooms, K., de Maeyer, P., Fack, V., van Assche, E., & Witlox, F. (2012). Interpreting maps through the eyes of expert and novice users [Article]. *International Journal of Geographical Information Science*, 26(10), 1773-1788. <https://doi.org/10.1080/13658816.2011.642801>
- Ooms, K., Maeyer, P. D., Fack, V., Assche, E. V., & Witlox, F. (2012). Investigating the Effectiveness of an Efficient Label Placement Method Using Eye Movement Data. *The Cartographic Journal*, 49(3), 234-246. <https://doi.org/10.1179/1743277412Y.0000000010>
- Opach, T., Golebiowska, I., & Fabrikant, S. I. (2014). How Do People View Multi-Component Animated Maps? [Article]. *Cartographic Journal*, 51(4), 330-342. <https://doi.org/10.1179/1743277413y.0000000049>
- Opach, T., & Nossun, A. S. (2011). EVALUATING THE USABILITY OF CARTOGRAPHIC ANIMATIONS WITH EYE-MOVEMENT ANALYSIS.
- Peng, C. F., Liao, W. H., & Ieee. (2016, Dec 11-13). Evaluation of interactive data visualization tools based on gaze and mouse tracking. *IEEE International Symposium on Multimedia-ISM* [Proceedings of 2016 IEEE International Symposium on Multimedia (ISM)]. 18th IEEE International Symposium on Multimedia (IEEE ISM), San Jose, CA.
- Popelka, S., Burian, J., & Beitlova, M. (2022). Swipe versus multiple view: a comprehensive analysis using eye-tracking to evaluate user interaction with web maps [Article]. *Cartography and Geographic Information Science*, 49(3), 252-270. <https://doi.org/10.1080/15230406.2021.2015721>
- Popelka, S., Herman, L., Rezník, T., Parilová, M., Jedlicka, K., Bouchal, J.,...Charvát, K. (2019). User Evaluation of Map-Based Visual Analytic Tools [Article]. *ISPRS International Journal of Geo-Information*, 8(8), 22, Article 363. <https://doi.org/10.3390/ijgi8080363>
- Popelka, S., Vondrakova, A., & Hujnakova, P. (2019). Eye-tracking Evaluation of Weather Web Maps [Article]. *ISPRS International Journal of Geo-Information*, 8(6), Article 256. <https://doi.org/10.3390/ijgi8060256>
- Putra, H. F., & Ogata, K. (2022). NAVIGATING THROUGH GOOGLE MAPS USING AN EYE-GAZE INTERFACE SYSTEM [Article]. *International Journal of Innovative Computing, Information and Control*, 18(2), 417-432. <https://doi.org/10.24507/ijicic.18.02.417>
- Qiao, L. G., & Wu, M. G. (2024). An exploratory tag map for attributes-in-space tasks [Article]. *International Journal of Applied Earth Observation and Geoinformation*, 133, 14, Article 104127. <https://doi.org/10.1016/j.jag.2024.104127>
- Qvarfordt, P., Beymer, D., & Zhai, S. (2005). RealTourist - A study of augmenting human-human and human-computer dialogue with eye-gaze overlay. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics),
- Roth, R. (2015). Interactivity and Cartography: A Contemporary Perspective on User Interface and User Experience Design from Geospatial Professionals. *Cartographica*, 50, 94-115. <https://doi.org/10.3138/cart.50.2.2427>
- Roth, R. E., Ross, K. S., & MacEachren, A. M. (2015). User-Centered Design for Interactive Maps: A Case Study in Crime Analysis. *ISPRS International Journal of Geo-Information*, 4(1), 262-301.
- Rzeszewski, M., & Kotus, J. (2019). Usability and usefulness of internet mapping platforms in participatory spatial planning [Article]. *Applied Geography*, 103, 56-69. <https://doi.org/10.1016/j.apgeog.2019.01.001>

- Saint-Marc, C., Villanova-Oliver, M., Davoine, P.-A., Pams Capoccioni, C., & Chenier, D. (2017). User testing of dynamic geovisualizations: lessons learned and possible improvements for cartographic experiments. *International Journal of Cartography*, 3(1), 88-101. <https://doi.org/10.1080/23729333.2017.1301347>
- Santos-Torres, A., Zarranonandia, T., Díaz, P., & Aedo, I. (2018). Exploring interaction mechanisms for map interfaces in virtual reality environments. ACM International Conference Proceeding Series,
- Siirtola, H., & Rähkä, K. J. (2011). Using gaze data in evaluating interactive visualizations. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics),
- Slomska, K. (2018). Types of maps used as a stimuli in cartographical empirical research [Article]. *Miscellanea Geographica*, 22(3), 157-171. <https://doi.org/10.2478/mgrsd-2018-0014>
- Spur, M., Houel, N., & Tourre, V. (2020). Visualizing multilayered geospatial data in virtual reality to assess public lighting. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences - ISPRS Archives,
- Šařinka, Ā., Morong, K., & Stachon, Z. (2017). The Hypothesis Platform: An Online Tool for Experimental Research into Work with Maps and Behavior in Electronic Environments. *ISPRS International Journal of Geo-Information*, 6(12), 407.
- Torrens, P. M., & Kim, R. (2024). Evoking embodiment in immersive geosimulation environments [Article]. *Annals of Gis*, 30(1), 35-66. <https://doi.org/10.1080/19475683.2024.2316601>
- Woodworth, J. W., Broussard, D., & Borst, C. W. (2020). Designing Tools To Improve Collaborative Interaction in a VR Environment for Teaching Geosciences Interpretation. Lecture Notes in Informatics (LNI), Proceedings - Series of the Gesellschaft für Informatik (GI),
- Wu, M. G., & Qiao, L. G. (2022). Designing Metaphorical Multivariate Symbols to Optimize Dockless Bike Sharing [Article]. *Cartographic Journal*, 59(3), 220-238. <https://doi.org/10.1080/00087041.2022.2097759>
- Zagata, K., Medynska-Gulij, B., & Horbiński, T. (2024). Impact of the mini-map on the interpretation of spatial situations in the virtual geographical space of a video game [Article]. *Cartography and Geographic Information Science*. <https://doi.org/10.1080/15230406.2024.2410472>
- Zhang, C., Liao, H., & Meng, J. (2025). Evaluating the performance of gaze interaction for map target selection [Article]. *Cartography and Geographic Information Science*, 52(1), 82-102. <https://doi.org/10.1080/15230406.2024.2335331>
- Zhang, C. B., Liao, H., Huang, Y. B., & Dong, W. H. (2023). Evaluating the Usability of a Gaze-Adaptive Approach for Identifying and Comparing Raster Values between Multilayers [Article]. *ISPRS International Journal of Geo-Information*, 12(10), 20, Article 412. <https://doi.org/10.3390/ijgi12100412>
- Zhang, M., Gong, Y., Deng, R., & Zhang, S. (2022). The effect of color coding and layout coding on users' visual search on mobile map navigation icons [Article]. *Frontiers in Psychology*, 13, Article 1040533. <https://doi.org/10.3389/fpsyg.2022.1040533>
- Zhou, X. M., Viola, I., Alexiou, E., Jansen, J., & Cesar, P. (2023, Oct 16-20). QAVA-DPC: Eye-Tracking Based Quality Assessment and Visual Attention Dataset for Dynamic Point Cloud in 6 DoF. *International Symposium on Mixed and Augmented Reality* [2023 IEEE International Symposium on Mixed and Augmented Reality, ISMAR]. 22nd IEEE International Symposium on Mixed and Augmented Reality (ISMAR), Sydney, AUSTRALIA.