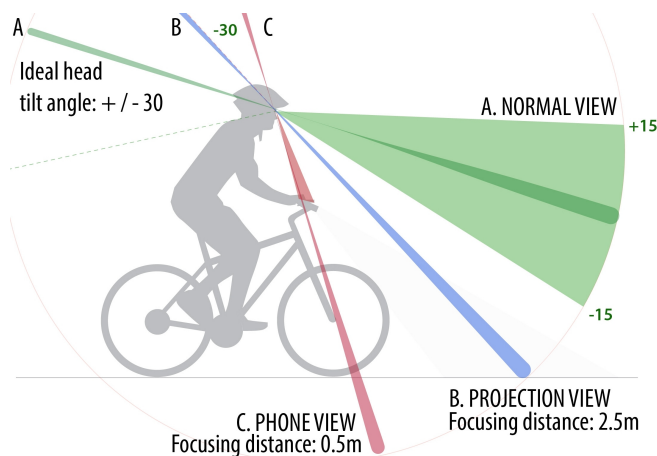








we evaluated two alternative display types for map navigation during cycling and factors other than display size affecting this task. One such visuo-spatial factor was eye-to-digital information distance (EI), which can be understood as the radius of a circle whose center is the cyclist's face and ends at the phone view or the projected view (Figure 5). In our study, the map was either visible at an arm's length from the eyes of the cyclist or on the ground in front of them. Besides EI, another factor is normal-view-to-digital information distance (NVI). There is thus a distance between the normal view and the information displayed by the mobile and by the projection. For the cyclist, the normal view is ahead, towards the road. The normal view is characterized by the field of view (FOV) and the line of sight directed ahead (A) (Figure 5). If digital information is presented outside of the FOV, the cyclist's head is required to move towards that information. In our study, the information was the map, requiring a head tilt to enable seeing the projection view (B) or the phone view (C) (Figure 5).



**Figure 4.** Line of sight and field of view in: A) normal view, B) projection view, and C) phone view.

The mobile's EI is less than the projector's, so the eye focuses faster on the projection. This is because the projection is closer to the normal view and in the FOV, as suggested by one subject. The NVI for the mobile is larger than it is for the projector, resulting in a larger angle during the head tilt. This difference in information placement, together with display size, could be the reason why the mental demand is perceived higher for the mobile phone than for the projector display. For the projected map, we noticed that head tilts had shorter duration and smaller angles, probably because the projected map is closer to the field of view. The experiment provided statistically non-significant data on head tilt frequency differences between devices. However, the data for both devices was remarkably close to the eye glance frequency found by researchers studying car driver attention and behavior for different GPS configurations [2].

### CONCLUSION AND FUTURE WORK

This paper presented a mobile system, Smart Flashlight, designed to evaluate bicycle map navigation using a mobile phone versus using a projector. The mobile phone display

could be used for navigation during the day, while the projector could serve as both flashlight and map during the night. This interaction method for navigation could be applied to other settings, such as hiking, swimming, or driving. To reliably measure and test objective factors such as completion time and head tilt frequency, we suggest i) controlling subject's cycling proficiency, ii) controlling subject's map navigation skills, and iii) controlling the GPS performance.

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