Press Release

Taking a Fresh Look at the Smartphone

New ZEISS study shows digital companions are significantly changing how we move our eyes

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Our eyes never stay still. Humans change their gaze roughly three times per second with quick, targeted movements of the eye known as saccades.[1] The direction of our gaze depends on the current object of interest, and naturally also on the current situation[2], be it a conversation, a stroll through the city or focused physical activity.

Head movements play a role in our gaze behavior as well. In the case of natural gaze behavior, the head tends to move slower than the eyes[3], and head movement is often initiated after eye movement. Only in very rare cases do the eyes and the head face in exactly the same direction when one's gaze is aimed at a specific object. That is relevant for the design of eyeglass lenses. If the movement of the head always perfectly match that of the eyes, the eyes would always gaze through the centers of the lenses. If the head does not move with the eyes, or if this movement is minimal, other areas of the lens are used. It is therefore of central importance when designing innovative eyeglass lenses to know which areas of the lens are used in the current form of gaze behavior and in different use cases of the lens.

Precision eyeglass lenses designed for pre-presbyopes and presbyopes and optimized for everyday use with digital devices have been available on the market since 2014/2015 in the form of ZEISS Digital eyeglass lenses and Digital Inside Technology for all ZEISS progressive lenses. But just as daily life continues to change dynamically as a result of digitalization, research and development activities at ZEISS Vision Care and at the ZEISS Vision Science Lab, located at the University of Tübingen, continue to pursue the question of how to incorporate measurable changes in gaze behavior into the design and function of modern eyeglass lenses.

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[1] Amit, Roy, Dekel Abeles, Izhar Bar-Gad, and Shlomit Yuval-Greenberg. 2017. “Temporal Dynamics of Saccades Explained by a Self-Paced Process.” Scientific Reports 7(1):886.
[2] Castelhano, M. S., M. L. Mack, and J. M. Henderson. 2009. “Viewing Task Influences Eye Movement Control during Active Scene Perception.” Journal of Vision 9(3):6–6. / Yarbus, Alfred L. 1967. “Eye Movements During Perception of Complex Objects.” Pp. 171–211 in Eye Movements and Vision. Boston, MA: Springer US.
[3] Zangemeister, Wolfgang H., Ashby Jones, and Lawrence Stark. 1981. “Dynamics of Head Movement Trajectories: Main Sequence Relationship.” Experimental Neurology 71(1):76–91.

Smartphones and gaze behavior

Smartphones are an undeniable part of everyday life. While early cell phones were designed merely for making and receiving mobile phone calls—and in some cases also for writing text messages—today's smartphones demand both our auditory and visual attention to a much greater extent. In 2015, ZEISS introduced Digital Inside Technology in response to the significantly shorter viewing distances used with digital devices as compared to other objects such as books, as well as to the fact that the user's gaze is forced to switch more frequently between long-distance and close-distance viewing. Today, smartphone use has become more dynamic - indeed, more varied and diverse. Seventy percent of consumers, for example, use more than one device[4]. Smartphones are often used in conjunction with other activities - we use them to read while eating breakfast, they serve as navigational tools on strolls through the city, and we use them throughout the day to communicate. A good example of the broadening functional scope of smartphones is IoT (Internet of Things) devices[5], which can be controlled remotely and independent of location.

Not only are smartphones often held closer to the user's eyes than books[6], they also impact gaze behavior. The ZEISS Dynamic Gaze Study, conducted by the ZEISS Vision Science Lab in Tübingen, Germany, looks at the effects that smartphones have on gaze behavior in everyday situations.

Dynamic Gaze Study: Method

The Dynamic Gaze Study tracked the eye movements of eleven test subjects (aged 22 to 29) during three everyday situations. Each situation - working at a desk, engaging in a conversation, and walking through a building - was performed for ten minutes, once with a smartphone and once without. The test subjects were asked to use the smartphone as they would in their everyday lives. The study collected 600 minutes of video and eye-tracking data.

The data were analyzed using various parameters, including gaze distribution; the center, width and height of the gaze distribution; the duration of fixations on the smartphone; and the length and rate of saccades.

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[4] The Vision Council. (2016). Eyes overexposed: The digital device dilemma. 2016 Digital eye strain report: https://visionimpactinstitute.org/wp-content/uploads/2016/03/2016EyeStrain_Report_WEB.pdf (US Survey)
[5] For example, Bosch sold over 50 million IoT devices in 2018 alone: https://www.bosch-presse.de/pressportal/de/de/bosch-bringt-das-internet-der-dinge-iot-voran-182336.html
[6] Bababekova, Yuliya, Mark Rosenfield, Jennifer E. Hue, and Rae R. Huang. 2011. “Font Size and Viewing Distance of Handheld Smart Phones.” Optometry and Vision Science 88(7):795–97.

The results: Smartphones significantly impact our gaze distribution

The false color plot (Figure 1) shows how often the gaze dwells in a specific direction, with and without the smartphone. One can easily see that the gaze distribution is altered by the use of the smartphone. Calculations performed on the data show a significant vertical widening of the gaze distribution, as well as a significant downward shift in the gaze distribution average. This is – to the best of our knowledge – the first time this has been demonstrated in a scientific study.

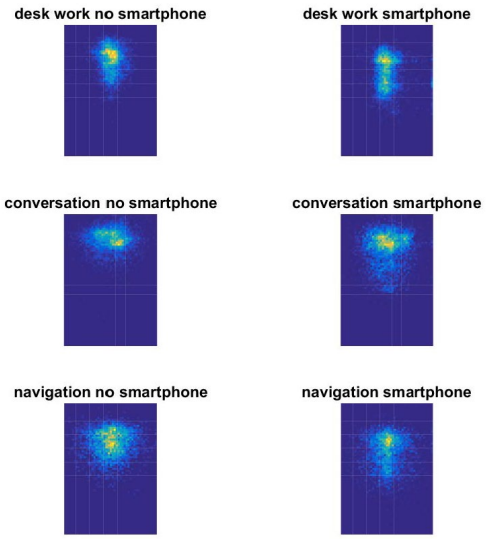

Figure 1: False color plot: number and distribution of gazes in all three test situations. The plots on the left represent activities performed without a smartphone, and the plots on the right were performed with a smartphone. The lighter/yellow regions represent more frequent gazes.

Further analyses performed on the data, in which gazes at the smartphone were evaluated separately from independent gaze behavior[7], showed that smartphone gazes undergo a significant downward shift relative to the center, straight-line gaze. This can be clearly seen in the contour line diagrams[8] in Figure 2. The separate, red smartphone gazes are consistently directed downward, meaning that head movement mimics eye movement less, or barely at all. As this relates to the design of eyeglass lenses, this means that smartphones are viewed primarily through the lower region of the lens.

[7] Independent: gaze behavior when there is no specific gaze task being performed in the test situation
[8] Curves connecting points of the same value or similar appearance on geographical, meteorological and similar maps.

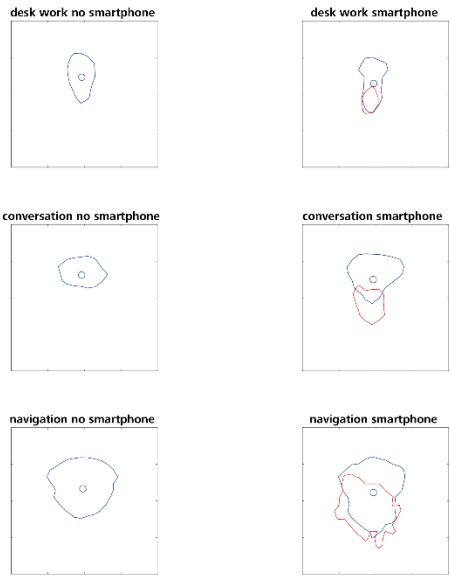

Figure 2: Contour lines showing the gaze distribution in all three situations, with (right) and without (left) a smartphone. Gazes at the smartphone are designated separately with red lines. The blue lines describe areas where gaze dwells primarily.

Further calculations also showed that the gaze fixates on the smartphone longer than it would in the given periphery if no smartphone were present.[9] This means that the head does not move towards the periphery as much when the smartphone is present as it would in similar situations without a smartphone. Hence, smartphones have a very specific, demonstrable effect on our gaze behavior.

Conclusion: Designing eyeglass lenses to meet new demands

The results of the ZEISS Dynamic Gaze Study have been incorporated into the new design of the ZEISS SmartLife eyeglass lenses. The fact that smartphones significantly impact gaze distribution means that lens designs need to be optimized accordingly - across all lens types.

ZEISS SmartLife Single Vision is a unique, single vision lens designed for the dynamic lifestyles of today which features an optimized region for close range viewing located specifically in the lower area of the lens. Smartphone use and its associated gaze distribution are incorporated into the design of the lens by means of an optimization to the room-object model. Given the widespread use of smartphones across all age groups, all SmartLife designs—including ZEISS SmartLife Digital lenses and progressive lenses—have been improved to meet these new challenges.

[9] That is, if there were another visual target in this area.

ZEISS is a foundation company with focus on science, investing roughly 11 percent of sales revenue in research and development. The ZEISS SmartLife range of eyeglass lenses is just one example of ZEISS' commitment to incorporating scientific findings and knowledge about consumers and consumer behavior into its products.

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Contact for the press
ZEISS Vision Care
Maria Conrad
Phone: +49 (0) 7361 591-1378
Email: maria.conrad@zeiss.com

www.zeiss.com/newsroom
www.zeiss.com/vision-news

About ZEISS
ZEISS is an internationally leading technology enterprise operating in the fields of optics and optoelectronics. In the previous fiscal year, the ZEISS Group generated annual revenue totaling more than 6.4 billion euros in its four segments Semiconductor Manufacturing Technology, Industrial Quality & Research, Medical Technology and Consumer Markets (status: 30 September 2019).

For its customers, ZEISS develops, produces and distributes highly innovative solutions for industrial metrology and quality assurance, microscopy solutions for the life sciences and materials research, and medical technology solutions for diagnostics and treatment in ophthalmology and microsurgery. The name ZEISS is also synonymous with the world's leading lithography optics, which are used by the chip industry to manufacture semiconductor components. There is global demand for trendsetting ZEISS brand products such as eyeglass lenses, camera lenses and binoculars.

With a portfolio aligned with future growth areas like digitalization, healthcare and Smart Production and a strong brand, ZEISS is shaping the future of technology and constantly advancing the world of optics and related fields with its solutions. The company's significant, sustainable investments in research and development lay the foundation for the success and continued expansion of ZEISS' technology and market leadership.

With over 31,000 employees, ZEISS is active globally in almost 50 countries with around 60 sales and service companies, 30 production sites and 25 development sites. Founded in 1846 in Jena, the company is headquartered in Oberkochen, Germany. The Carl Zeiss Foundation, one of the largest foundations in Germany committed to the promotion of science, is the sole owner of the holding company, Carl Zeiss AG.

Further information at www.zeiss.com

ZEISS Vision Care
ZEISS Vision Care is one of the world's leading manufacturers of eyeglass lenses and ophthalmic instruments. The unit is allocated to the Consumer Markets segment and develops and produces offerings for the entire eyeglass value chain that are distributed globally under the ZEISS brand.