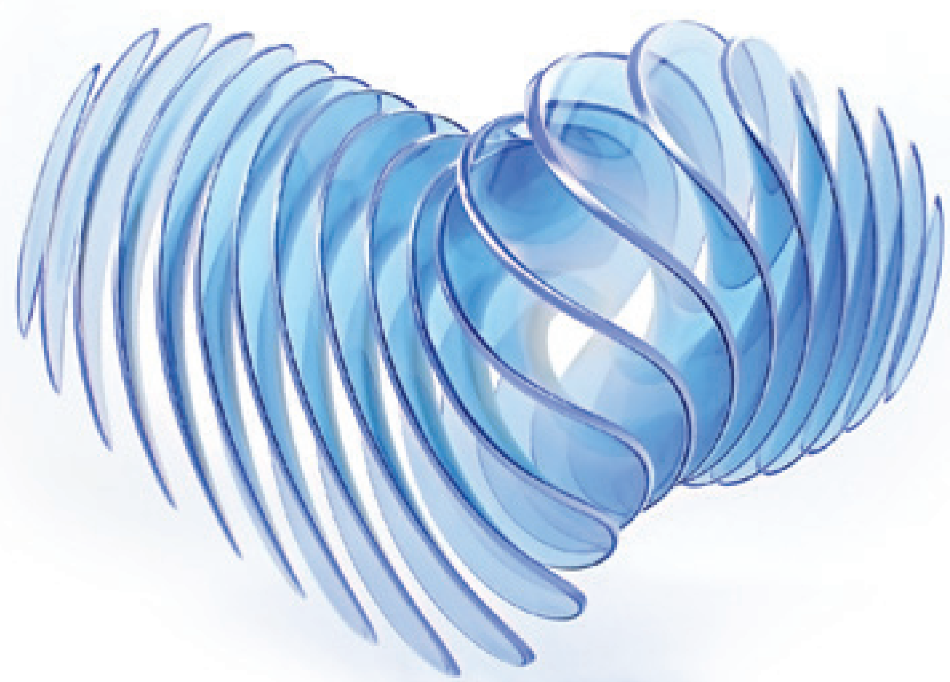
White Paper

ZEISS SmartLife Individual 3 White Paper Part I

Science Behind | The evolution of SmartLife & the ZEISS Global Vision Study 2020/2021



ZEISS

Seeing beyond

ZEISS SmartLife Individual 3 lenses

The evolution of ZEISS SmartLife

Accelerated digitalization continues to influence everyone's lives. This ongoing trend substantially impacts viewing needs and behavior in a rapidly changing world. Although we share similar lifestyles and visual behaviors, our visual needs continue to evolve as we age. Building on prior technology advancements, innovations, and growing knowledge in the understanding of visual behavior for improved lens design optimizations, the introduction of the 1st generation ZEISS SmartLife lenses in 2019 marks the beginning of a new era of premium lenses that address the challenges of modern vision and age-related vision needs in our connected and mobile lifestyles. This made ZEISS SmartLife lenses the go-to, all-day, premium RX lens portfolio for everyone's dynamic visual behavior - for all-day comfortable vision & ease of view in any distance & direction.

In 2020, our lives were disrupted and have been constantly changing ever since. The rise of new tech further accelerates these continual changes. Our dynamic visual behavior has evolved and will adapt to these new circumstances. Particularly for the manufacturing of individual eyeglass lenses, it is crucial to understand our lifestyle habits and visual behavior holistically to be able to develop products that enable better, clearer, and healthier vision, in line with our age-related visual requirements - and are no longer based purely on statistics and standard parameters or on a "one size fits all" approach.

Phygital Reality and Active Aging

Change is a constant in human life and in our lifestyles. And within the last couple of years, the COVID-19 pandemic has fundamentally changed the way we work, learn, connect, and shop. Although underlying structural trends such as the rise of mobile work, changing consumer preferences, and the increasing use of video telephony, 5G digital networks, the Internet of Things, and artificial intelligence have been around for some time, COVID-19 may well be described as "the great accelerator," accelerating the existing global trend towards the use of modern technologies.[1] Although online activity declined to some extent as face-to-face interactions became possible again, the solutions people turned to during the height of the pandemic appear to have had a lasting impact on digital behavior, forming new habits around working, learning, exercising, shopping, and socializing.[2] Consumers now rely on digital tools to complete and engage in daily activities both at home and on the go. While generation X and baby boomers have increased their reliance on the internet and online shopping, young consumers don't care whether activities are physical or virtual; they no longer distinguish between the two. In our modern "phygital" reality, consumer lifestyles span the physical and digital worlds, where we can seamlessly live, work, shop, and play, both in person and online.[3]

Beyond lifestyle, also demographics are changing. Projections on global population development still see a slight growth overall. One of the most obvious trends is the aging of the population. Between 2015 and 2050, the proportion of people over 60 in the global population will almost double (2.1 billion), while the number of persons aged 80 years or older is expected to triple (426 million).[4] Most countries, including the U.S., Europe, and some Asian countries, are projected to see the share of their population that is 65 and older surpass the share that is younger than 15 already as of 2030.[5]

Despite the fact that the population is undoubtedly aging, we must refrain from applying familiar stereotypes. We observe that this aging population is more active than ever, in both dimensions: physical and digital. For example, there is no longer the typical old person. Today many 70 or 80-year-olds can retain similar physical and mental abilities as much younger people and are much more active and engaged. "Active Aging" became a concept promoted by various organizations and institutions already in the late 1990's to address challenges faced by the labor market. In 2002 the World Health Organization (WHO) gave a new twist to the concept by emphasizing the prevention of health problems.[6] Today the term has become a description for maintaining health, safety, and participation in society in old age to ensure a good quality of life in later years.

ZEISS Global Vision Study 2020/2021

How did the recent changes in everyday life affect spectacle lens wearers and their typical visual behavior? How do changes relate to different age groups with specific visual demands and individual, yet age-related vision challenges? Which factors influence visual demands and subsequently visual behavior? Can these factors be reliably and holistically assessed by subjective self-reports as appropriate and realistic foundation for the design and optimization process of individualized lenses?

To answer these questions, ZEISS collected more than twelve million data records from eyeglass wearers across the world over a period of more than two years. The starting point was the analysis of the existing, vast ZEISS MyVision Profile database, which comprised subjective evaluations of the lifestyle of more than 300,000 consumers worldwide. In a second step, this extensive database was enhanced by a real-life study collecting objective measurements applying state-of-the-art visual behavior monitoring and analysis technology. Both data pools were combined and form the basis of the ZEISS Global Vision Study 2020/21.

Part 1: ZEISS MyVision Profile Analysis 2019 and 2021

The analysis of the ZEISS MyVision Profile online database allowed ZEISS to assess the subjective lifestyle and self-reported activity evaluation of more than 300,000 people aged between 20 and 90 years (Figure 1) from more than 50 countries all over the world.

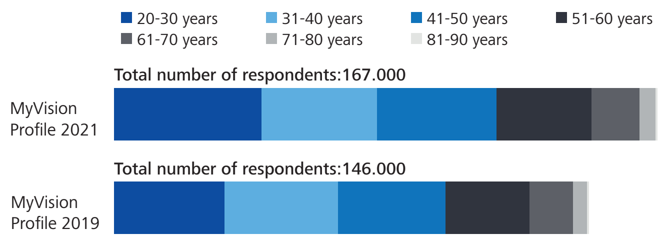


Figure 1. Number of respondents in the specified age groups from 2019 and 2021.

To assess the recent lifestyle changes and how they affected spectacle lens wearers, full datasets of more than 146.000 respondents for the year 2019 were compared with data from more than 167.000 respondents for the year 2021. The wide dispersion of geographic locations (Figure 2) and year-round monitoring thereby buffered the specific impact of wave-like pandemic dynamics on the assessment of activities of "normal" everyday life.

Figure 2. Geographic locations of respondents to the ZEISS MyVision Profile online survey in 2019 and 2021.

Within the online survey, study participants provided a self-assessment of their personal lifestyle based on a questionnaire of 30 questions covering the evaluation of vision challenges, work & daily life, digital lifestyle, & mobility – altogether providing millions of data points for in-depth analysis.

Results from self-reports on spectacle lens wearer's lifestyle

Across all respondents and all age groups, it is clearly visible from the ZEISS MyVision Profile database, that the majority spends much time on digital devices and doing near work activities (Figure 3).

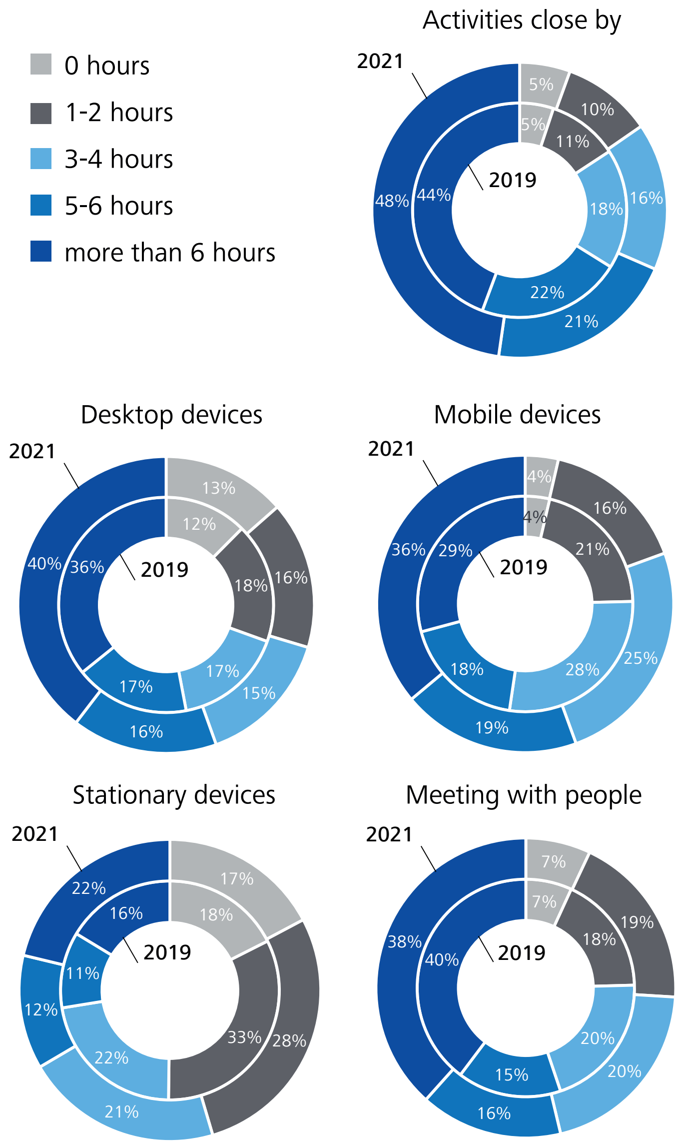


Figure 3. Percentage share of time spent on different activities as reported by ZEISS MyVision Profile respondents in 2019 (inner circles) vs. 2021 (outer circles).

As already in 2019, most respondents reported spending more than 6 hours with activities in close distance (near work), like reading, writing, or similar. Likewise, the biggest share of respondents reported spending more than 6 hours on mobile devices (for activities like socializing, working, reading, or something similar), reaching almost the same share of people who reported to spend more than 6 hours on desktop devices working, surfing, communicating, or doing something similar. In comparison, for time spent on stationary devices, answers were more diverse, with the biggest share of respondents indicating spending between 1 and 2 hours per day on TVs, games, videos, or similar – as already in 2019.

Focusing on the changes in self-reported occupation times between 2019 and 2021, it becomes apparent that people spend even more time with digital devices and near-based activities

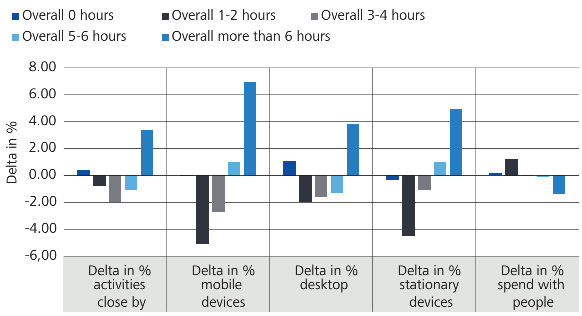


Figure 4. Average changes in self-reported time spent on given activities by ZEISS MyVision Profile respondents in 2021 vs. 2019.

(Figure 4). Interestingly, this increase is visible across all age groups, with a surprisingly uniform pattern in direction of change between 2019 and 2021 from 20 up to 90 years of age (Figure 5). Looking however at the absolute amount of time people spend with specific tasks, there is a clear difference between age groups in the distribution of percentage shares. Even if the increase of digital device usage is similar across all age groups (about ~ 5%), there are significant variations when it comes to the absolute duration within the respective age groups. This can best be seen for mobile device usage (Figure 6). Whereas among the younger cohorts (20-40 years of age) the average time of mobile device usage is more than 6 hours per day, in the elder generation (70 plus), the majority spends only 2 hours or less per day on mobile devices. Interestingly, the majority (69%) of 50- to 70-year-olds reports in 2021 more than 3 hours of mobile device usage, with 27% of 50- to 60-year-olds and 17% of 60- to 70-year-olds even claiming more than 6 hours, respectively, while in 2019 many (39%) still reported less than 2 hours of mobile device usage.

Taken together, a consistent picture emerges from the comparison of ZEISS MyVision Profile answers from 2021 vs 2019 that clearly reflects the global lifestyle changes of the past few years. In general, they are visible across all age groups, but with variations when it comes to absolute numbers, time shares of distinct activities, and overall lifestyle patterns. Whereas younger generations already were immersed by "screen time" all day and all night long – even still further increasing from 2019 to 2021 – it also forced older generations to join the digitalization, using digital devices on average now for 3 hours or more daily.

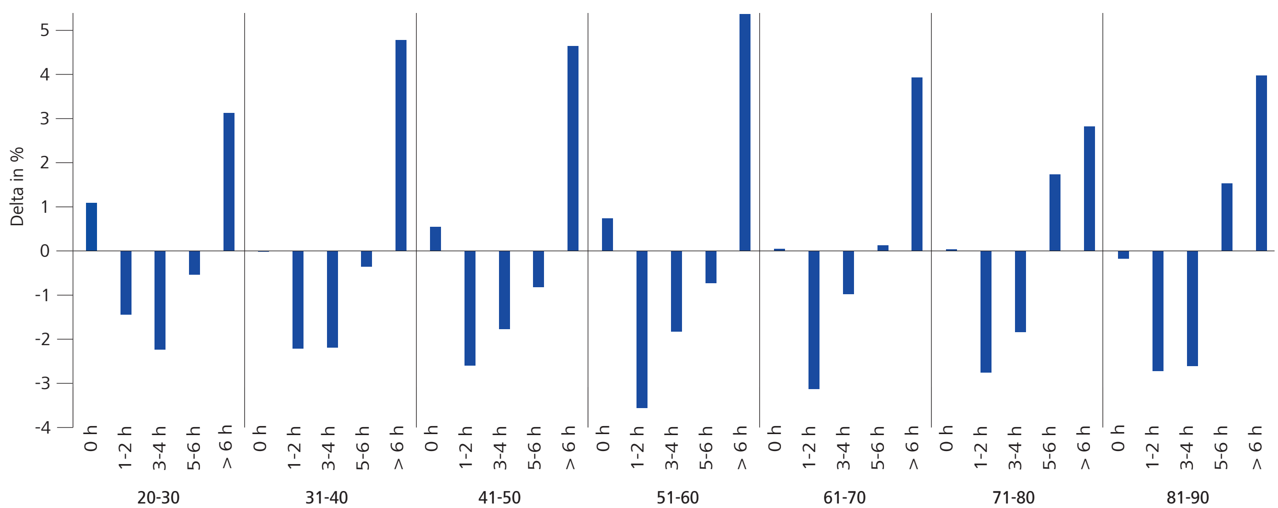


Figure 5. Average changes in self-reported time spent on given activities by ZEISS MyVision Profile respondents in 2021 vs. 2019 split by age groups.

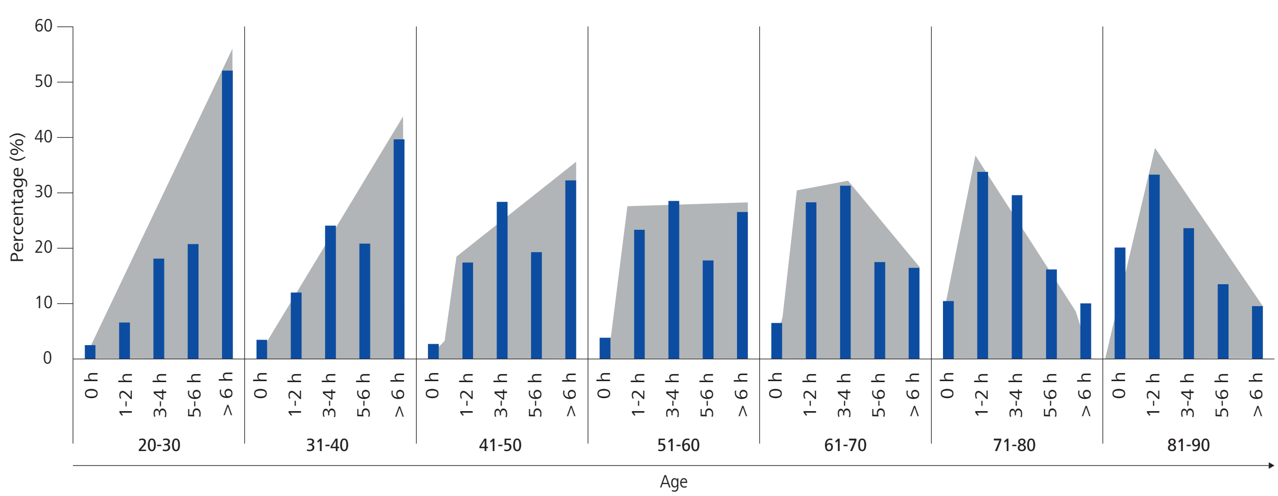


Figure 6. Percentage share of time spent on mobile devices as reported by ZEISS MyVision Profile respondents 2021 split by age groups.

These observations reassure the hypothesis of a major and fundamental impact on the visual needs and visual behavior in the respective age groups.

Are self-reports a valid representation of reality?

Despite the consistency of the observations with the expected directions reflecting known overall lifestyle changes, it is important to consider that the results described above were based on self-reports. It is well known from various research fields how little subjective evaluation of time spent at distinct tasks typically correlates with objective measures (i.e., the extent to which self-report measures of usage reflect actual objective usage). Prominent examples include the recall bias when assessing the duration and intensity of physical activity[8], sleep[9], food intake[10], and lately there is also plenty of research on social media usage. When directly compared, these studies suggest that subjective social media use is largely unrelated to objective use[11], with large proportions of study participants actually over-estimating their social media usage.[12], [13]

But why are self-reports so prone to error? The answer lies in the way our brain manages memories. When we talk about memory, we immediately think of remembering. Following this perspective, forgetting would be seen as a failure of memory.[14] Lately, neurophysiological research on memory has however changed in perspective and tells us, that (active) forgetting is just as important as remembering.[15] The most intuitive explanation for the need of forgetting would be, that there is just not enough space to remember every detail of each of our actions in daily life. Considering the sheer number of brain cells and connections in our brain, there is however ample capacity to store many more memories than we actually do. A brief arithmetic excursion shows that if we reserve only 10% of the roughly estimated 80 to 90 billion neurons in the human brain for memories of specific events, computational estimates of capacity in auto-associative networks suggests that we could reliably store approximately one billion individual memories, and several orders of magnitude more if we consider sparsely encoded memories.[14]

Remembering everything comes however at a price as can be seen in neuropsychological case studies. A patient with “vast memory” that allows them to remember instances in exquisite detail, but who can only forget something if actively willing themselves to do so, is handicapped by this apparent super-human memory as it doesn’t allow them to generalize across instances.[16]

To keep us from getting insane and allow us to make well-informed decisions for the future, our brains had to develop a clever and efficient memory management system that allows individuals to exhibit flexible behavior and generalize past events to new experiences. Simplification is thus an essential component of adaptive memory. Memories are simplified to capture only the essentials, but not necessarily the intricate details of past events, and to do so, insignificant details must be forgotten.[14]

We do not remember days, we remember moments.
The richness of life lies in memories we have forgotten.
Cesare Pavese (This Business of Living)

This excursion into the neurophysiological basics of our memory demonstrates why traditional research applying self-reports fails to capture the gap between what people say they do versus what they actually do. Staying with the specific example of smartphone use, a true recall of behavior is not only complicated by the fact that smartphone use is habitual[17], and habitual behaviors are more difficult to estimate[18], but on top by the type and frequency of engagement triggered by the activity itself. Social networking app use may be particularly challenging to recall due to frequent notifications and alerts, which may trigger constant checking. In addition, most users access social media through multiple electronic devices and routinely switch between multiple social media platforms on a daily basis – a behavior referred to as “platform swinging”.[13]

In the case of lifestyle assessment to inform new lens design optimizations, it is not only important to know what we actually do – whereby the task at hand is fundamental for the visual requirements to see clearly in all directions and distances, but even more so how we do it. And this particularly relates to age-related differences in visual behavior.

Part 2: Visual behavior monitoring in real-life

With the second part of the ZEISS Global Vision Study 2020/21, ZEISS therefore took its insights generation one important

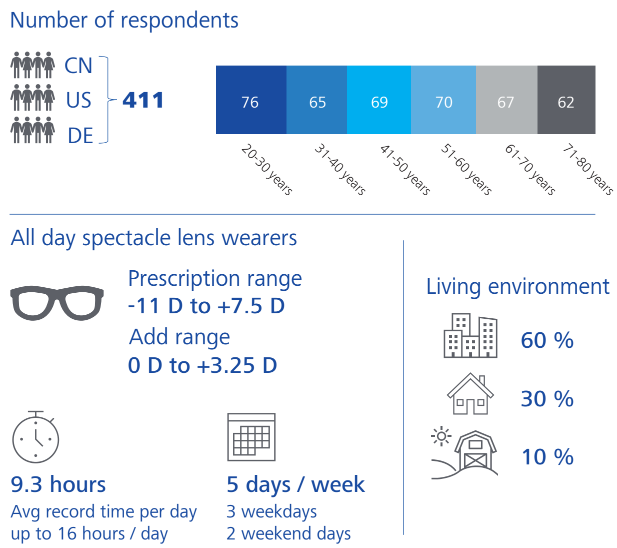


Figure 7. Overview of demographic information of the study participants.

step further: enhancing self-reports on spectacle lens wearer's everyday activities with millions of objective measurements on visual and oculomotoric behavior collected in real life. To do so, ZEISS partnered with leading industry experts specialized on behavioral market research and understanding consumer's actual (visual) behavior rather than reported or claimed behavior, applying state-of-the-art technologies and smart data science.

More than 400 spectacle lens wearers from three countries, Germany, China, and the USA, participated in the study. Study participants were selected to reflect a wide range of age groups, prescriptions, spectacle lens types, occupations, and living environments (see Figure 7 for a summary of demographic data). All participants received a visual behavior data logger that was attached to the temple of their personal spectacle lens frames and accompanied them throughout the day while objectively recording vision distances, ambient light levels, UV exposure, orientation, and motion. The visual behavior tracker derived activity profiles based on a patented algorithm applying artificial intelligence which sets all collected data in relation to each other for objective categorization of individual tasks. Additionally, participants were asked to precisely characterize what they did at a given time via a lifestyle questionnaire. To derive a robust and realistic assessment of the visual demands of individual spectacle lens wearers, in contrast to a predetermined laboratory set-up like in the past, data was collected in real life, i.e., in everyday situations and diverse environments over a time course of several days.

Results on visual behavior monitoring vs self-reports

A direct comparison of self-reported data with objective data from visual behavior monitoring clearly shows vast discrepancies in what we recall we were doing vs what we actually do. Across all age groups, the self-reports did not match the objective observables as exemplified for a set of pre-clustered vision tasks in (Figure 8). In general, the relative trends in time shares remained consistent for intermediate and distance-driven vision tasks (e.g., cooking or baking, socializing with friends, watching television on a big screen), but there were significant differences between subjective and objective data when it came to dynamic visual behavior (e.g., sports activities, shopping, walking). (Figure 9) shows a comparison of average observed vs reported time shares on visual activities grouped for vision distances and visual behavior. The size of the bubbles thereby corresponds to the percentage share of actual (observed) time on clustered visual activities. All bubbles that lie above the dotted line show that study participants underestimate their time share in self-reports, while study participants overestimate the time share of bubbles lying below the dotted line. The data comparison clearly shows – across all age groups – that we subjectively overestimate absolute visual interaction with handhelds and underestimate dynamic visual interaction. At the same time, these two visual activity clusters together account for more than half of the visual activity observed in normal everyday life.

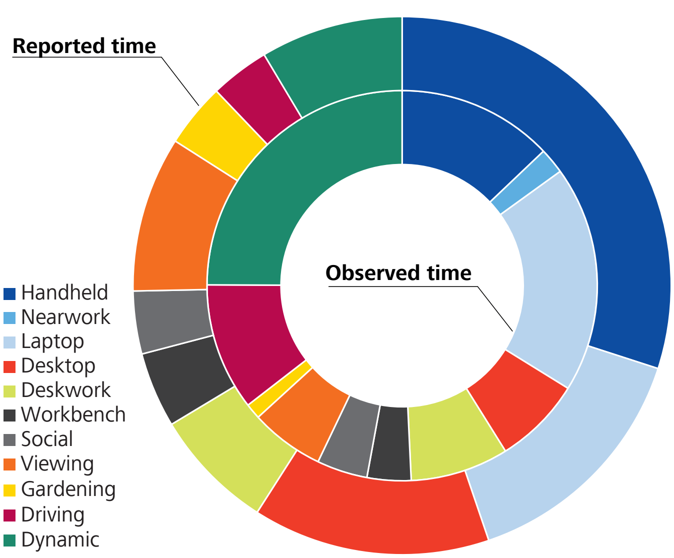


Figure 8. Observed vs reported time study participants exemplified for selected activities grouped in pre-clustered vision tasks (e.g., workbench includes tasks like cooking, baking, and arts & crafts). Percentage share of total period observed over all age groups is displayed.

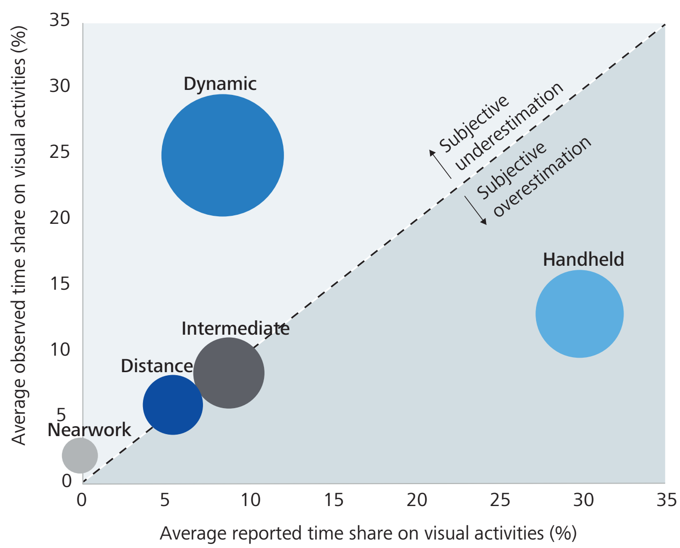


Figure 9. Comparisons of self-reported time share and objective visual behavior monitoring show discrepancies in the assessment of near, dynamic, and handheld vision tasks across all age groups.

Particularly interesting was the usage of mobile devices. As expected, the self-reported usage of mobile devices was much higher than the objective measurement on "screen vision". By diving deeper into this observation, in addition to the challenges in estimating time engaging with mobile devices detailed above, ZEISS could identify an additional challenge that is critical for visual behavior evaluation: the discrepancy between "time using a mobile device" and actually "looking on a mobile device".

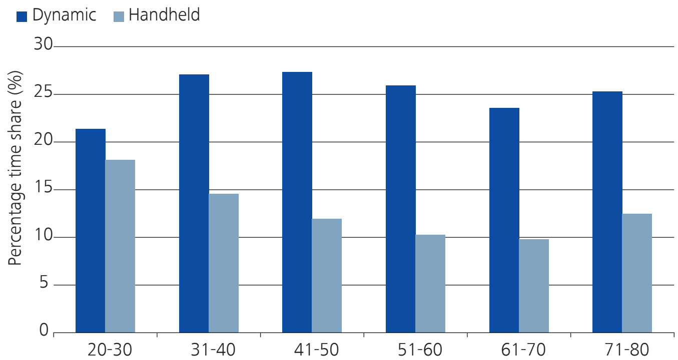


Figure 10. Observed time share on activities differs substantially between different age groups. Percentage share of total period observed is displayed for defined age groups.

Objective monitoring confirms age-dependent patterns in visual behavior

The analysis of the ZEISS MyVision Profile database showed substantial differences in the time share of reported daily tasks with age. Although the direct comparison between reported and observed engagement in real-life visual tasks revealed significant discrepancies, these age-related patterns were also evident in the objective visual behavior monitoring data. This is exemplified in (Figure 10) for the observed clusters of "dynamic" and "handheld" tasks, the two activity clusters where the discrepancies between reported and observed time share were most apparent. As such, the time share on activities clustered by objective monitoring confirms the observation that the daily distribution of vision tasks varies significantly by age, which has significant implications for viewing distances, attention targets, and overall visual behavior.

Results on age-dependent visual behavior decoded in real-life

Studies show that visual behavior - i.e., "How you see", despite being determined by the visual targets – i.e., "What you see", is primed and defined (almost like a vision fingerprint) by the visual habits that were acquired (learned) over time. Our visual behavior is determined by the complex interplay of anatomy, physiology, vision motor control, or oculomotoric behavior, and visual habituation of a person.

Habituation describes the visual strategies a person learns and acquires over the lifespan to overcome vision challenges that come with growing older. Biological age impacts human life at various levels. Some elements of physical and cognitive performance can differ through lifestyle, learned behavior, genetic predispositions, but also from unpredictable factors. Compensation is a strategy to overcome and preserve functionality. Spectacle lenses are one of the tools to compensate for age-related vision challenges. The focal type of a lens – single vision, digital, or progressive addition lenses (PAL) – is an important influencer of visual habituation and therefore the acquired visual behavior.

By studying the holistic visual behavior in real life via the comprehensive analysis of data collected on vision distances, orientation, and motion, this impact becomes even more apparent. As one example, (Figure 11) shows the vertical head movements displayed as percentage up and down flexion recorded in the visual behavior monitoring study, separated for single vision lens wearers and PAL wearers by age. The course of the oculomotoric data from lens wearers aged 20 up to 80 years clearly shows the continuous change in visual behavior with increasing age.

Furthermore, the data highlights the influence of the visual tasks for which the lenses are used and the habituation to the particular lens design on overall visual behavior. A 45-year-old single vision lens wearer moves his or her head up and down vertically less than a 75-year-old single vision lens wearer. This could be due to the fact that single vision lenses in older people are usually reading glasses and therefore most likely to be used for "reading activities." Thus, the observed difference in visual behavior is likely due not only to age, but also to the activity or purpose of the lens. In contrast, a 45-year-old PAL wearer moves his or her

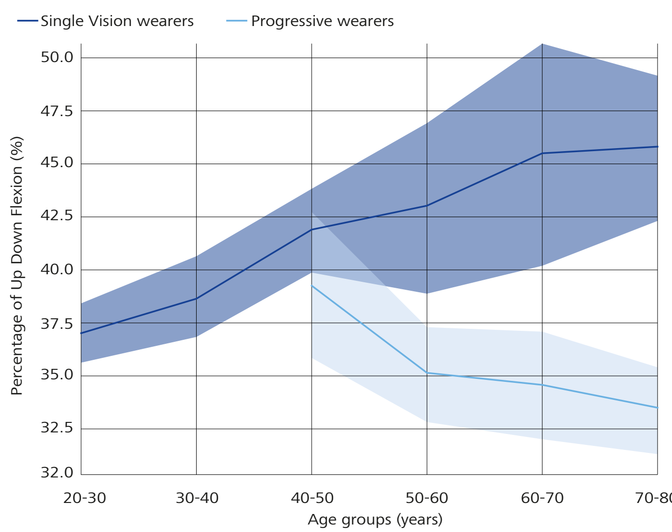


Figure 11. Vertical head movements for single vision lens wearers and progressive lens wearers by age.

head more than a 75-year-old PAL wearer, also suggesting that as a PAL wearer ages, he or she moves the head less and moves the eyes more instead – likely driven by the increase in addition power along the corridor within the progressive lens design.

The continuous change in visual behavior with increasing age that is clearly visible in (Figure 11) undermines the conclusion that a mere split in focal types of single vision, digital, progressive addition lenses is an over-simplification of typical age-related oculomotor performance, vision strategies, and holistic visual behavior. Lens designs need to be further customized to better reflect age-normal visual behavior, for example of a young progressive lens wearer vs an older progressive lens wearer.

To allow for an easy adaptation and smooth transition between lens types or increasing power profiles due to advanced visual needs, it is crucial to consider the lens wearer's habituated visual behavior and how this will change with the transition to easily adjust to new vision requirements with increasing age. While the consideration of age-dependent visual behavior in the typical focal types already forms the basis of the SmartLife lens portfolio, the new results further advanced the understanding of this need and provide holistic insights into how our visual behavior changes with age.

Summary of ZEISS Global Vision Study 2020/21

Following the 1st generation ZEISS SmartLife lenses, the ZEISS Global Vision Study with its two parts, the analysis of the vast ZEISS MyVision Profile database and the subsequent real-life study among spectacle lens wearers using advanced data logging technologies, showed that the trend towards our "always connected and mobile lifestyle" has continued and digital interaction times are further increasing across all age groups. The results of the ZEISS Global Vision Study highlighted that self-assessment of consumers on their daily activities and lifestyle can be helpful to learn more about the individual consumer and give directions for a solid lens recommendation, but they miss essential components to holistically represent a person's all-day everyday visual behavior, visual needs, and behavioral vision habits. Quantitative evaluations allowed us to show to what extent subjective assessments of the activity recorded by self-reports or questionnaires deviates from reality, i.e., the data measured by objective means. The overall refined findings provide a much more detailed assessment of vision needs across age groups, occupations, and lifestyle, while undermining that subjective data is not sufficient to truly customize a lens design.

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