

# Promotion of Proactive Behavioral Change to Prevent Human Error

## - Part 1 Longitudinal Changes in the Effects of Perceptual and Cognitive Functions on Strategic Driving Behavior in Older Drivers -

**Toshihisa Sato<sup>1)</sup> Hiroshi Yoshitake<sup>2)</sup> Yoshiko Goda<sup>3)</sup> Masashi Toda<sup>3)</sup> Motoki Shino<sup>2)</sup>**

*1) National Institute of Advanced Industrial Science and Technology (AIST)  
Tsukuba Central 6, 1-1-1 Higashi, Tsukuba, Ibaraki, 305-8566, Japan (E-mail: toshihisa-sato@aist.go.jp)*

*2) Institute of Science Tokyo  
2-12-1 Ookayama, Meguro, Tokyo, 152-8550, Japan*

*3) Kumamoto University  
2-39-1 Kurokami, Chujo, Kumamoto, Kumamoto, 860-8555, Japan*

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Although traffic fatalities in Japan have declined in recent years, older adults still account for more than half of all traffic-related deaths. Driver assistance technologies are therefore becoming increasingly important. However, many older drivers do not simply continue driving in the same way as they age. Instead, they often adapt their driving behavior by avoiding situations they find difficult or by driving more cautiously. Understanding these adaptive behaviors is essential for developing driver assistance systems that provide support only when it is truly needed and avoid unnecessary intervention. This study investigated how age-related changes in perceptual and cognitive functions influence strategic driving behavior, which refers to the ways drivers plan, regulate, and adapt their driving in everyday situations. Rather than focusing solely on functional decline, the study examined how older drivers modify their behavior to compensate for age-related changes.

A longitudinal analysis was conducted using data from the Data Repository for Human Life-Driving Anatomy (Dahlia). Data from 106 older drivers (49 males and 57 females) were analyzed at two time points separated by four years. Participants were, on average, 67.9 years old at the first assessment and 71.4 years old at the second. Measures of perceptual and cognitive function included dynamic visual acuity, night vision, the Useful Field of View (UFOV), the Trail Making Test (TMT), and the AIST Cognitive Aging Test, which evaluates attention, planning, working memory, and task-switching ability. Strategic driving behavior was assessed using questionnaires on self-reported driving characteristics, compensatory driving behaviors, driving style, and workload sensitivity. Relationships between cognitive functions and driving behavior were examined using path analysis.

Three major findings emerged from the longitudinal comparison. First, some driving behaviors became more strongly associated with specific cognitive functions over time. Poorer performance on TMT-B, a measure of executive control and mental flexibility, showed increasingly strong relationships with both avoidance of adverse driving conditions and sensitivity to driving at a slower-than-preferred pace. Drivers with poorer TMT-B performance tended to feel greater perceived burden when driving at a slower-than-preferred pace while also showing a lower tendency to avoid potentially risky driving situations. In addition, the influence of UFOV, which reflects the range of visual information that can be processed at a glance, on avoidance of adverse driving conditions became stronger over time.

Second, the cognitive factors underlying compensatory driving behaviors changed with age. Avoiding secondary tasks while driving, such as operating audio controls, was initially associated with reduced working memory. Four years later, both working memory and task-switching ability were related to this behavior. Similarly, conscientious driving behaviors, such as reliably making complete stops, were associated mainly with TMT-B performance at the earlier assessment but became more closely related to task-switching ability at the later assessment. These findings suggest that older drivers continuously adjust their compensatory strategies as cognitive aging progresses.

Third, some behavioral changes were influenced by factors beyond perceptual and cognitive functions. Perceived decline in vehicle operation ability was initially associated with planning ability but later became associated with both planning ability and self-efficacy, including decisiveness as one of its components. This finding indicates that subjective perceptions of driving decline are shaped not only by cognitive performance but also by broader psychological processes.

These results have important implications for designing personalized driver assistance systems. Support that helps drivers maintain attention on driving and reduces task-switching demands may be particularly beneficial for individuals experiencing declines in cognitive flexibility. At the same time, assistance that is appropriate for one driver may be perceived as unnecessary or intrusive by another who has already adapted successfully to age-related changes. Personalized support strategies should therefore consider both cognitive function and the ways drivers compensate for their limitations.

In conclusion, this longitudinal study demonstrated that the effects of perceptual and cognitive functions on strategic driving behavior change over time. The cognitive factors underlying compensatory driving behavior are not fixed and, in some cases, psychological factors beyond cognitive function become increasingly important. These findings highlight the value of longitudinal research for understanding adaptive driving behavior and provide useful insights for the development of personalized driver assistance systems for older adults.