The relationship between central and peripheral motion perception and hazard perception abilities of younger and older drivers

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BACKGROUND

- Hazard Perception is a key skill for driving
  - Assessed using video-based tests: hazard perception test (HPT)[1]
  - Slower HPT reaction times have been associated with increased crash rates[2,3], and poorer on-road driving performance[4,5]

- Motion perception relevant for driving: driver and environment in motion
  - Slower HPT reaction times relate to poorer motion perception in central vision[6], but whether the same relationship exists in peripheral vision is unknown, despite some traffic-related hazards occurring in our peripheral vision
  - Evidence of deterioration of motion perception with aging[7-9]

AIMS

- To determine whether poorer motion perception is associated with slower HPT reaction times in younger and older drivers
  - Considering different motion stimuli: some motion tasks may be more related to HPT
  - Including central and peripheral vision: peripheral motion perception may be more relevant as hazards also occur in peripheral vision

MATERIALS AND METHODS

- 65 visually heathy current drivers (35 younger adults; mean age 25.5 ± 4.3 years and 30 older adults; mean age: 71.0 ± 5.4 years)
- Binocular viewing, two eccentricities: central (stimulus center at 0^{o}) and peripheral (stimulus center at 15^{o} rightwards)

- Visual measurements included:
  - Visual acuity (LogMAR using an ETDRS chart)
  - Contrast sensitivity measured by a customized method in Psychopy[10]
  - Four motion perception tasks (Figure 1):
    - Minimum displacement to identify direction of motion of a 3^{o} dot pattern (D_{min}), **Figure 1a**
    - Contrast detection threshold for a 3 c/° drifting Gabor (truncated at ±3 σ=4.05°), **Figure 1b**
    - Translational global motion coherence of a 10^{o} random dot kinematogram (RDK), **Figure 1c**
    - Biological motion of a point light walker (PLW) of 4^{o} x 7.4^{o} in the presence of noise dots, **Figure 1d**

- HPT reaction times recorded using a touchscreen (**Figure 2**)
  - 28 videos from driver's point of view
  - Raw HPT times for each hazard converted to a z-score (standardized responses using the mean and SD of all responses in the sample to each hazard). Mean z-score averaged across 28 videos for each participant

- Analyses:
  - Pearson correlations between HPT z-scores and visual measurements in central and peripheral vision
  - Age-adjusted multiple regression analysis considering HPT results, visual measures, and age group

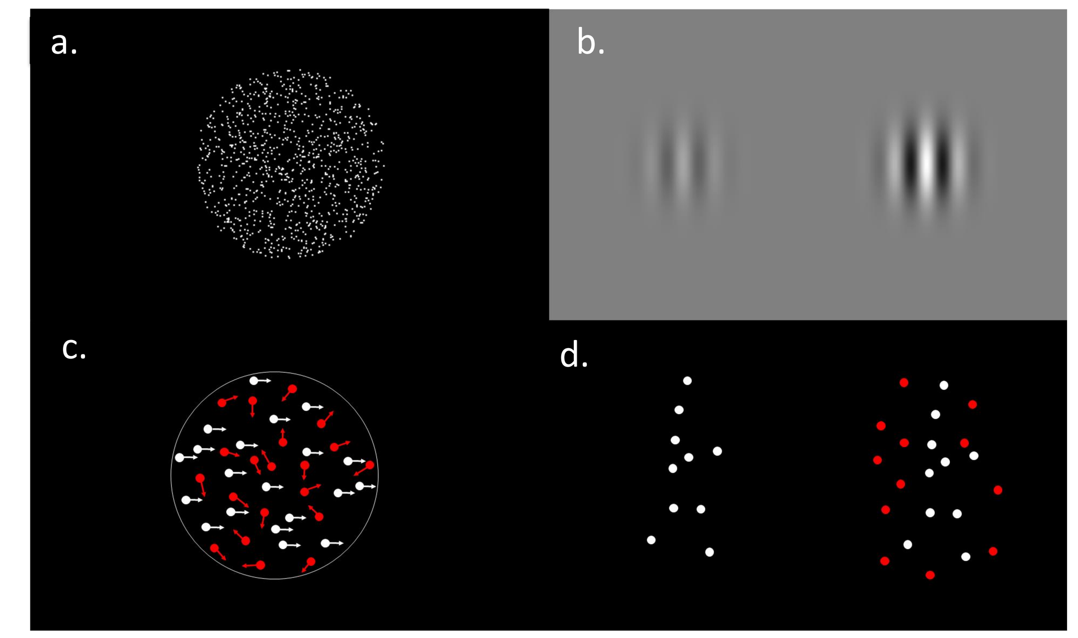

Figure 1. Schematic illustrations of motion stimuli. a. Single frame of a dot pattern for D_{min} testing. b. Example of two Gabors with 50% and 100% of contrast. c. RDK pattern used to test translational global motion. In this illustration, dots in white represent those moving coherently, and in red the noise dots which move randomly. d. Point light walker facing rightwards without and embedded in noise dots (left and right respectively). Red dots in c. and d. are just for illustration purposes.

Figure 2. Screen captures from one HPT video. Participants were required to press the hazard, circled here in yellow for demonstration purposes: in the actual HPT test, no indicator of the hazard location was provided. Time is recorded in seconds from the start of the video (bottom right time).

RESULTS

- HPT reaction times were not significantly different between age groups: $t(63)=-0.87, p=0.40$
- Significant correlations between HPT scores and motion contrast and D_{min} in central vision (r=0.30 and 0.28 respectively) and D_{min} in peripheral vision (r=0.34, **Table 1**).
- After adjusting for age, peripheral D_{min} explains 12% of the variability in the hazard perception test results ($R^2=0.12$, **Table 2**).

Table 1. Pearson correlations between HPT z-scores and visual measurements in central and peripheral vision. Significant results are highlighted in red.

Measurement	r	p-value	Bootstrapped 95% CI (2.5, 97.5%)
Central vision			
Visual Acuity	0.02	0.85	-0.23, 0.48
Contrast sensitivity	0.22	0.07	-0.04, 0.48
Motion contrast	0.30	0.02	0.06, 0.48
Translational global motion	0.13	0.31	-0.10, 0.36
Biological motion	0.12	0.34	-0.20, 0.40
D_{min}	0.28	0.02	0.00, 0.50
Peripheral vision			
Contrast sensitivity	0.29	0.02	0.04, 0.51
Motion contrast	0.14	0.27	-0.10, 0.40
Translational global motion	0.10	0.41	-0.12, 0.34
Biological motion	0.18	0.15	-0.06, 0.41
D_{min}	0.34	0.005	0.12, 0.54

Table 2. Regression coefficients R^2 for multiple regression models with and without adjustment for age in central and peripheral vision. Significant results are highlighted in red.

Measurement	R^2	p-value	R^2 adjusted for age	p-value
Central vision				
Visual Acuity	<0.01	0.85	0.01	0.64
Contrast sensitivity	0.05	0.07	0.05	0.20
Motion contrast	0.09	0.02	0.09	0.05
Translational global motion	0.02	0.31	0.02	0.50
Biological motion	0.01	0.34	0.02	0.56
D_{min}	0.08	0.02	0.09	0.06
Peripheral vision				
Contrast sensitivity	0.08	0.02	0.08	0.07
Motion contrast	0.02	0.27	0.02	0.50
Translational global motion	0.01	0.41	0.02	0.55
Biological motion	0.03	0.15	0.04	0.31
D_{min}	0.12	0.01	0.12	0.02

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CONCLUSIONS

- Motion perception tests are better predictors of HPT scores than traditional measures of vision used to assess fitness to drive (i.e. visual acuity)
  - D_{min} and motion contrast mildly correlated with HPT results: timely detection of hazards on a video-based test does not solely rely on visual functions
- Ability to detect small motion changes in peripheral vision is a relevant cue to detect driving-related hazards in a computer-based HPT test
- We did not report age differences in HPT reaction times
- As poorer HPT performance is related with increased crash rates and poorer on-road driver performance, future studies should explore whether D_{min} and motion contrast are useful to identify unsafe road users.

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