Aging effects on expectancy use in driving scenes as assessed by the ideal observer
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Introduction

Aging and driving

- Older drivers tend to have more accidents (e.g., National Highway Traffic Safety Administration, USA, 2009; Ryan, Legge, & Rossman, 1998)
- Older drivers tend to reduce their driving (e.g., Glasgow, 2000) or cease driving altogether (e.g., Keay, Munoz, Turano, et al., 2009)
    - having a negative impact on Quality of Life (e.g., Windsor et al., 2007)

Aging, driving, and visual attention

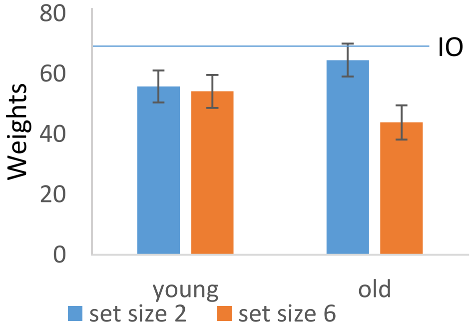
- Aging has effects on cognition (e.g., see Salthouse, 2000; Butler & Zacks, 2006) and vision (e.g., see review in Sekuler & Sekuler, 2002).
- Clear aging effects upon visual attention: the Useful Field of View (UFOV), (e.g., Sekuler, Bennett, & Mamelak, 2000), a visual search task.
- Performance in the UFOV predicts driving performance in the aged (e.g., Owsley et al., 1998).

Visual attention, cueing tasks, and aging effects

- However, results of studies of aging effects in cueing are mixed (review in Swan et al., 2015), possibly due to a reliance on reaction times.

Ideal observer analysis of aging effects in cueing tasks (Swan et al., 2015)

- Proposed a Bayesian ideal observer analysis of cueing tasks (e.g. Eckstein, et al., 2002; Shimozaki, 2010)
- The Bayesian IO analysis quantifies the optimal use of information provided by a (predictive) cue.
- The measure: weight, with the ideal weight equal to the cue validity.
- 70% peripheral valid cue in a cued yes/no detection of a simple (2D Gaussian) target, set sizes 2 and 6
- Results, younger participants: The weights were not affected by set size and close to optimal (70).
- Results, older participants: The weights were less optimal with the larger set size.
- Conclusions: Older participants had difficulty with using the cue information as set size increased.



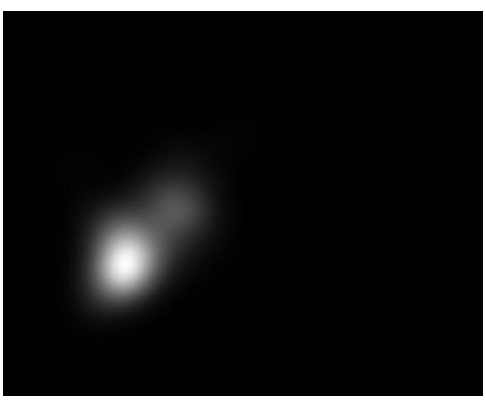
Study Aim: Extending the ideal observer for cueing to the use of expectations in naturalistic driving scenes

- Eckstein, Drescher, & Shimozaki (2006): demonstrated the application of the ideal observer for cueing to the use of expectations (prior knowledge) in more naturalistic scenes (e.g., a chimney on top of a roof).
- This study: assessing the use of expectations in driving scenes for both younger and older drivers.

1. Online pilot study: determining expectancy heat maps

- 172 participants (age: 22.31, sd=7.42, 142 female), self-reported UK drivers
- 150 grey-scale driving scenes from Birmingham, UK, presented online
- Scenes were free-viewed and also varied in size. For the control and main studies the scene size was 36.87° x 28.07°.

- **For each scene, participants were asked to indicate the most likely location of one driving-related target.**
- E.g.,this scene: 'Sign for directions?'
- Targets: Pedestrians (n=40), bicyclists (n=9), vehicles (n=40), motorcycles (n=4), bus stops (n=11), road signs (n=86)



- Each response was blurred (2D Gaussian, sd = 1.41°).
- **Blurred responses were summed and normalized to create expectancy heat maps.**

Example of an original image, filtered by the expectancy heat map.

Results, online pilot study

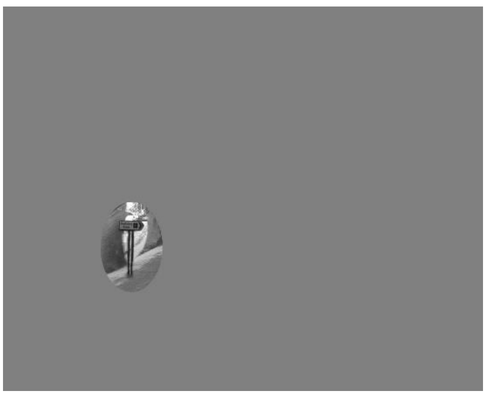
- **Peak expectancies tended to be below center** (2.73°, se = 0.14, 142 of 150 scenes), reflecting better vision/attention and dominance of information in the lower hemifield (e.g., Danckert & Goodale, 2003).
- **Peak expectancies tended to be left of center** left of center (8.58°, se = 0.40, 133 of 150 scenes), reflecting driving on the left in the UK.
- Most maps could be described as 1 or 2 contiguous areas (as in the example above).

2. Creating the stimuli: Photoshopping™ targets into scenes

- **Targets appropriate for each scene were cropped from another set of driving scenes and were 'photoshopped' into the peak (high) expectancy location and one lower (low) expectancy location.**
- 75 of the scenes were chosen (80 originally, 5 eliminated post-hoc) for the main study.
- Elimination was based upon expectancy maps (a single continuous area that was too small or too close to the edge, more than two contiguous areas) or ambiguous instructions during study.
- Target sizes were scaled roughly for distance (depth).

3. Control study: assessing local stimulus and eccentricity differences (between high and low expectancy locations)

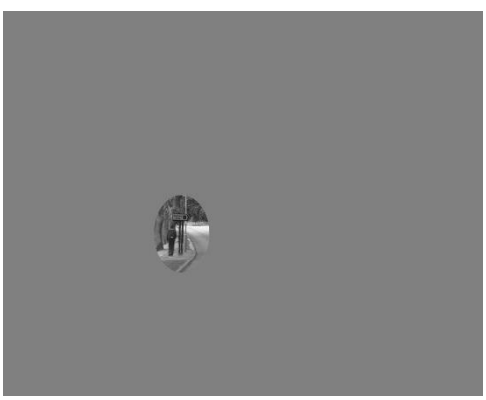
High expectation



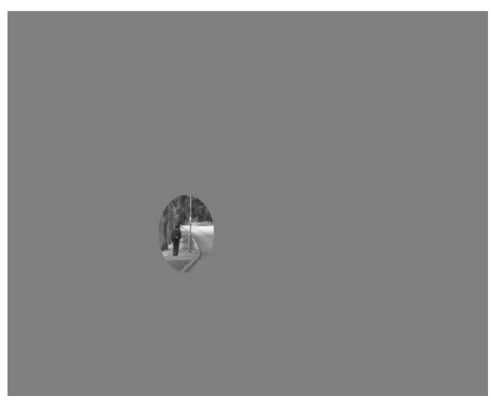
Target present

Target absent

Low expectation



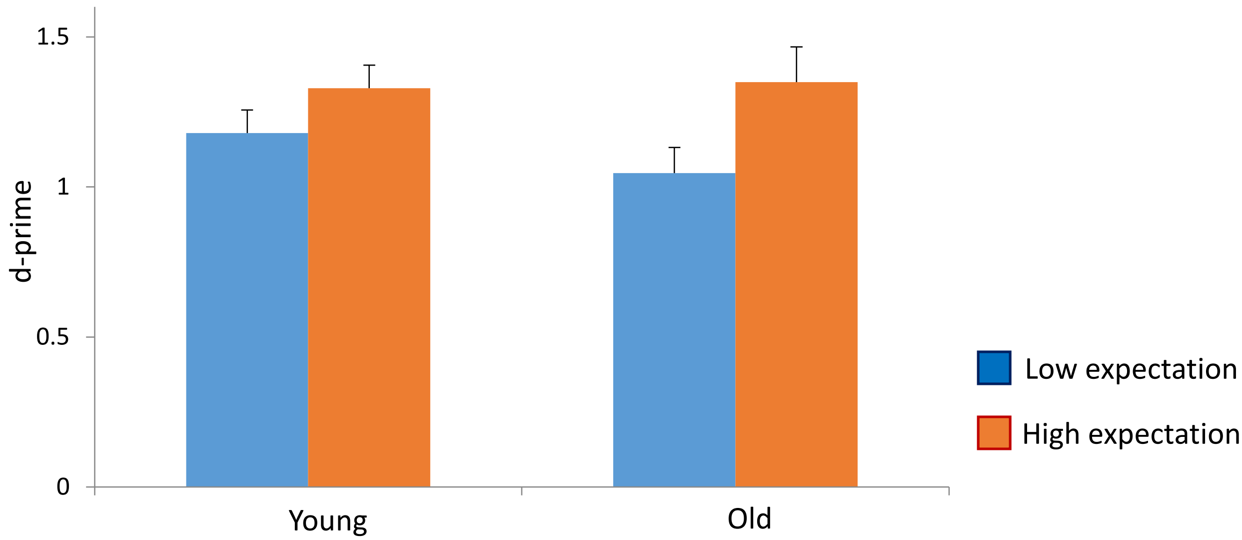
Target present



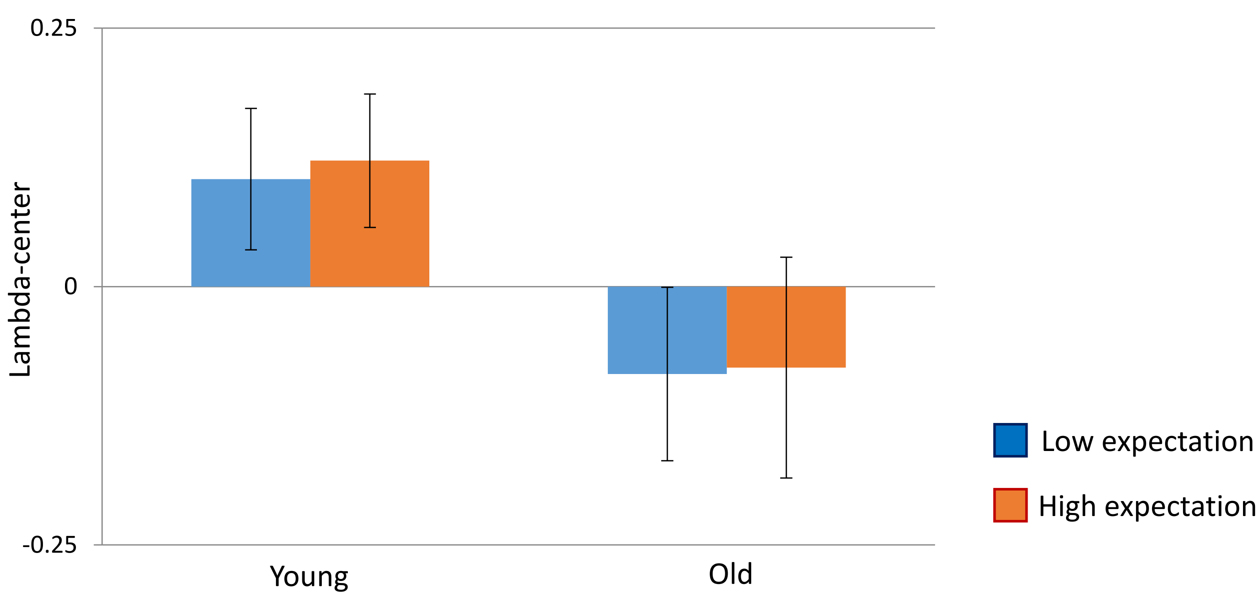
Target absent

- Task: yes/no detection, two conditions (high and low expectation)
- One trial: 1 sec preview text display giving target identity for the trial -> fixation cross (250ms minimum) -> stimulus
- Stimulus durations: Younger - 50ms, Older – 200ms
- Target present: targets presented with uniform grey backgrounds, except for elliptical areas surrounding targets (ellipses: 1.41° beyond maximum horizontal and vertical extents of targets)
- Target absent: created from the original scenes
- Eye-tracking ensured central fixation before stimulus presentation (Eyelink 1000, SR Research).
- Targets: Pedestrians (n=28), bicyclists (n=9), vehicles (n=11), motorcycles (n=1), bus stops (n=5) and road signs (n=21)

Results, control study, standard SDT yes/no detection analyses



- **Larger d-primes for high expectation locations ($F(1,46) = 28.45$, $p<.001$)**



- Lambda-center: criterion measure adjusted so that 0 = unbiased observer ($\lambda_{center} = \lambda - d'/2$, see Wickens, T., 2002)
- Older participants had more negative criteria, indicating a bias to say 'yes' ($F(1,46) = 6.564$, $p = 0.014$).

- **High expectation locations were**:
  - **More to the left** (8.78°, se = .054, vs 4.98°, se = 0.66, $p<.05$), and thus perceived to be closer to the participants
  - **And thus larger** (37.39 deg^2, se = 2.15 vs 23.09 deg^2, se = 1.00, $p<.05$), as expected from the difference in perceived depth.

4. Main study: assessing the use of expectancy

Target present, high expectation

Target present, low expectation

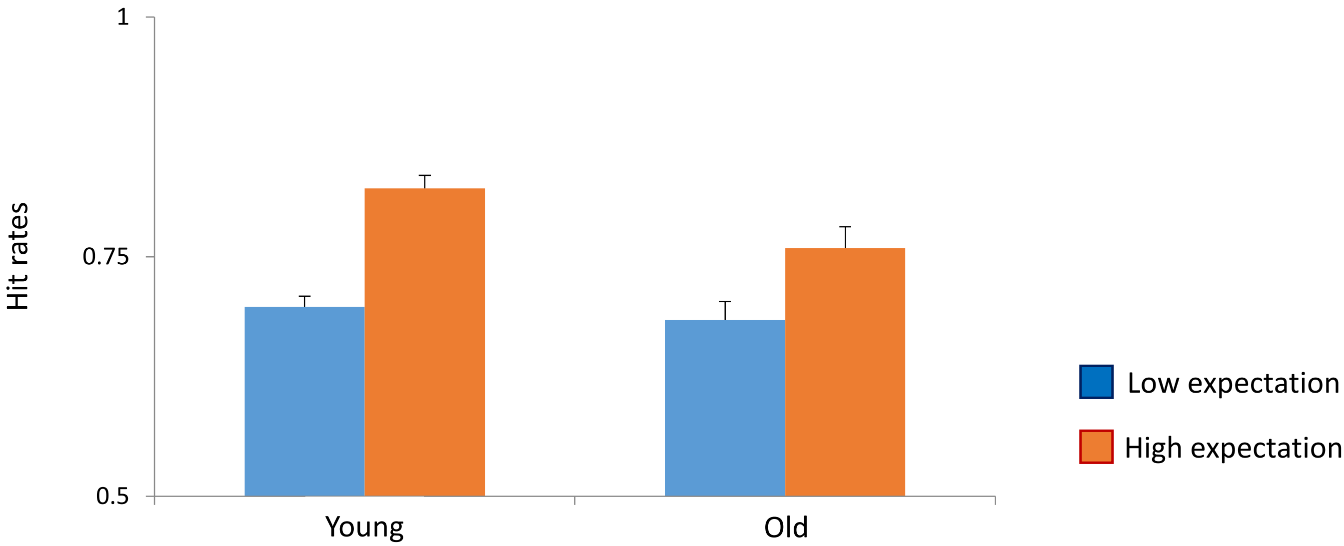
Target absent (original scene)

- Task: yes/no detection, three trial types (high expectation target present, low expectation target present, target absent)
- **Equivalent to a cued yes/no detection task with a set size (number of locations) of 2**
- One trial, younger participants ('flicker', e.g., Rensink, O'Regan, & Clark, 1997) : 1 sec preview text display giving target identity for the trial -> fixation cross (250ms minimum) -> target absent scene (150ms) -> uniform grey (blank, 50 ms) -> stimulus (50ms)
- One trial, older participants: 1 sec preview text display giving target identity for the trial -> fixation cross (250ms minimum) -> stimulus (200ms)

Modeling (based on the **Bayesian Ideal Observer for cueing tasks** (e.g., Eckstein et al., 2002; Eckstein et al., 2006; Shimozaki, 2010)

- Predicts maximal performance and **optimal use of the expectation (cueing) information**
- Use of expectation information quantified by the weight. For cueing tasks the ideal weight is the cue validity.
- Estimation of weight: normalized integration of heat maps for areas within ellipses for high and low locations
  - Weights: high=0.717, se=0.010; low=0.283, se=0.010
- **Two model fits:**
  - **Weighted: predicting optimal use of expectancy information, given the weights above**
  - **Equal (weights): predicting no use of expectancy information**
- **Difference in d-primes from control study were included in the model.** Ratio of d'_{low}/d'_{high} fixed, overall d' varied.

Results, main study



- **Larger hit rates for high expectation** ($F(1,45) = 77.42$, $p < .001$)
- Age X Expectation interaction; **younger participants had a larger high vs. low expectation difference** ($F(1,45) = 4.525$, $p = 0.039$)
- No difference (by age) for false alarms

Model fits

	$\chi^2(1)$	*p*	proportion	crit
younger, weighted	2.922	0.087	1.19	-0.96
younger, equal	30.54	<.001	1.18	-0.86
old, weighted	59.52	<.001	0.92	-0.94
older, equal	0.335	0.563	0.98	-0.84

- **Younger: fit to weighted model, no fit to equal model, suggesting use of expectancy**
- **Older: no fit to weighted model, fit to equal model, suggesting no use of expectancy**
- Proportions (proportion of 1 = same *d'*s as control study):
- **Younger proportions > 1 (p< .05), suggesting general improvement with full scene context**
- Negative criteria (p<.05), suggesting bias to say 'yes.'

Conclusions

For these more naturalistic driving scenes:

- **The model fits suggest the use of expectancy by the younger, but not the older, participants.**
- **The younger participants also seemed to benefit generally from the full scene context.**

Participants, control and main studies

- All UK drivers, Snellen acuity 20/30 or above (except for one older participant, 20/40)
- 49 younger : 25 (14 female) in control study (age=21.76 yrs, sd= 2.63); 24 (21 female) in experimental study (age=22.42 years, sd=2.82)
- 46 older (all passed the Mini-Mental State Exam, Folstein, Folstein, & McHugh, 1975): 23 (10 female) in control study (age=71.39 yrs, sd=5.37); 23 (7 female) in the experimental study (age = 71.04 years, sd=3.87)
- Driving experience: Younger participants-3.21 yrs, sd=2.11; older participants-46.26 yrs, sd=9.84