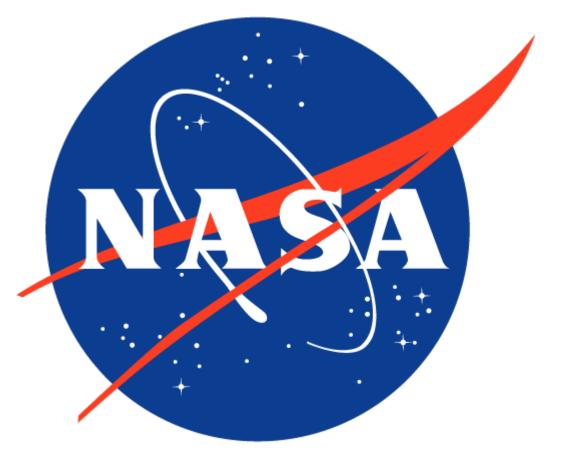
Impairment of Human Ocular Tracking with Low-Dose Alcohol

Terence L Tyson (SJSUF), Nathan H Feick (SJSUF), Dr. PatrickF Cravalho (SJSUF, Tiffany Tran (SJSUF), Dr. Erin Flynn-Evans (NASA), Dr. Leland Stone (NASA)

Previous studies have documented adverse effects of alcohol on oculomotor performance. For example, moderate-dose alcohol (yielding a Blood Alcohol Concentration or BAC of 0.04-0.1%) has been shown to decrease steady-state pursuit gain (Fransson et al., 2010, Clin Neurophysiol, 121(12): 2134; Moser et al., 1998, J Neurol, 245(8): 542; Roche & King, 2010, Psychopharmacology, 212(1): 33), to increase saccade latency (Moser et al., 1998, J Neurol, 245(8): 542; Roche & King, 2010, Psychopharmacology, 212(1): 33), to decrease peak saccadic velocity (Fransson et al., 2010, Clin Neurophysiol, 121(12): 2134; Roche & King, 2010, Psychopharmacology, 212(1): 33), and to increase the frequency of catch-up saccades (Moser et al., 1998, J Neurol, 245(8): 542). Here, we administered two doses of ethanol on different days, yielding moderate (0.06%) and low (0.02%)levels of initial BAC, to examine the effects on human ocular tracking over BACs ranging from 0.00 to 0.07%. Twelve subjects (8 females) participated in a 5-day study. Three days of at-home measurements of daily activity and sleep were monitored, followed by two laboratory days where, ~5 hours after awakening, we administered one of the two possible single doses of alcohol. Using a previously published paradigm (Liston & Stone, 2014, J Vis, 14(14): 12), we measured oculomotor performance multiple times throughout the day with three pre-dosing baseline runs and bi-hourly post-dosing test runs until the subject recorded a BAC of 0.00% for two hours. BAC was measured before each run using an Alco-Sensor IV breathalyzer (Intoximeters, Inc., St. Louis, MO). For each of the oculometric measures, for each subject, we computed the within-subject % deviation for each test run from their baseline averaged across their three pre-dosing runs. We then averaged the data across subjects in 0.01% BAC bins. Finally, we used linear regression to compute the slope and x-intercept (threshold) of the mean binned % deviation as a function of BAC. We found that pursuit initiation was impaired at very low BAC levels, with significant (p < 0.002) linear trends in latency (+1.3%/0.01%BAC) and initial acceleration (-4.6%/0.01%BAC) with extrapolated absolute thresholds at or below 0.01% BAC. We also found that steady-state tracking was impaired showing significant (p < 0.002) linear trends in gain (-3.8%/0.01%BAC) and catch-up saccade amplitude (+9.1%/0.01%BAC), again with extrapolated absolute thresholds around 0.01% BAC. We also found a significant (p < 0.02) increase in pursuit direction noise (+9.8%/0.01%BAC) with

an extrapolated absolute threshold below 0.01% BAC. Many aspects of ocular tracking are impaired in a dose-dependent manner beginning at a BAC level around 0.01%, with significant effects at levels lower than previously reported and up to 8-times lower than the legal limit for driving in most states.



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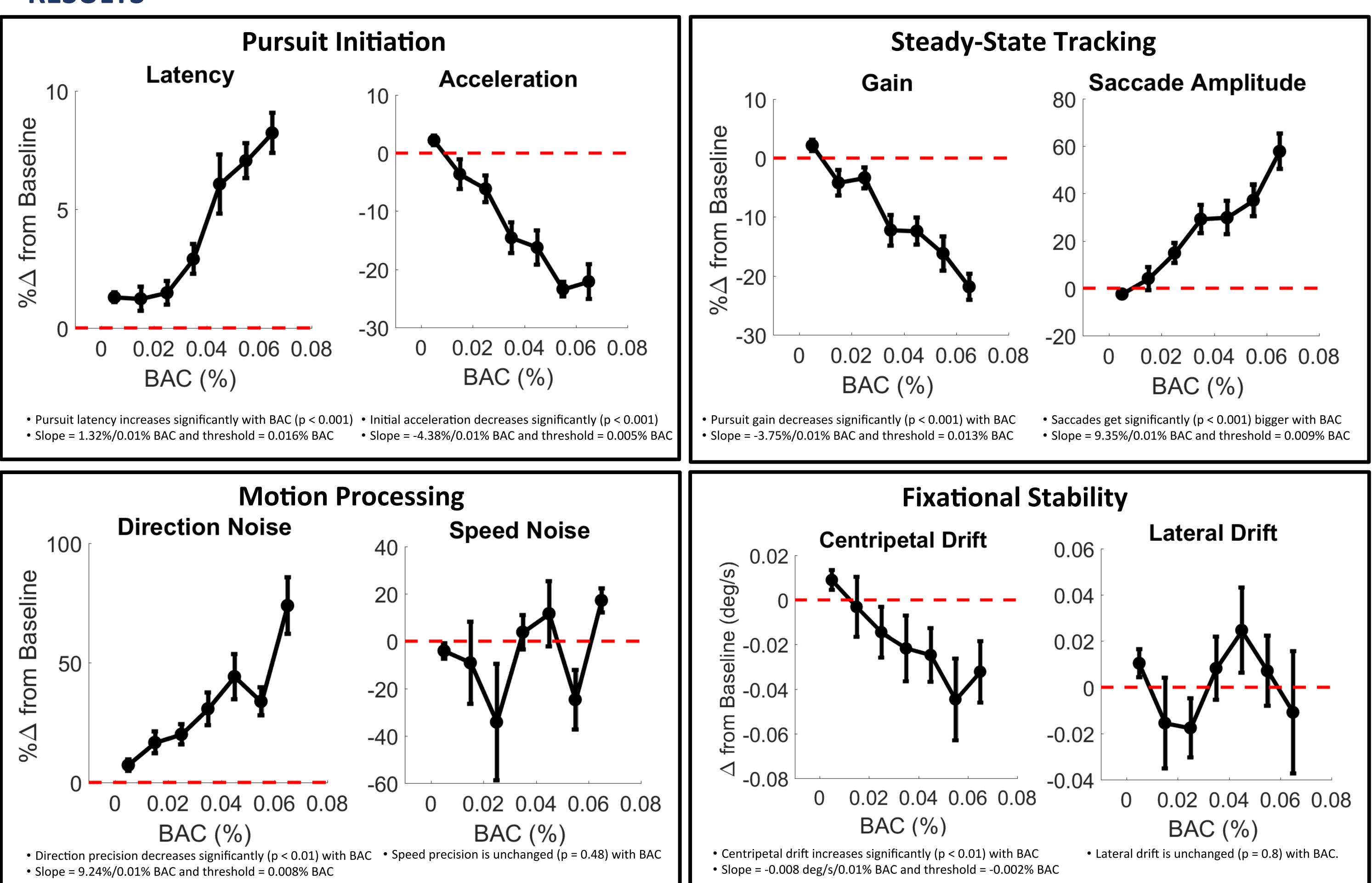
INTRODUCTION

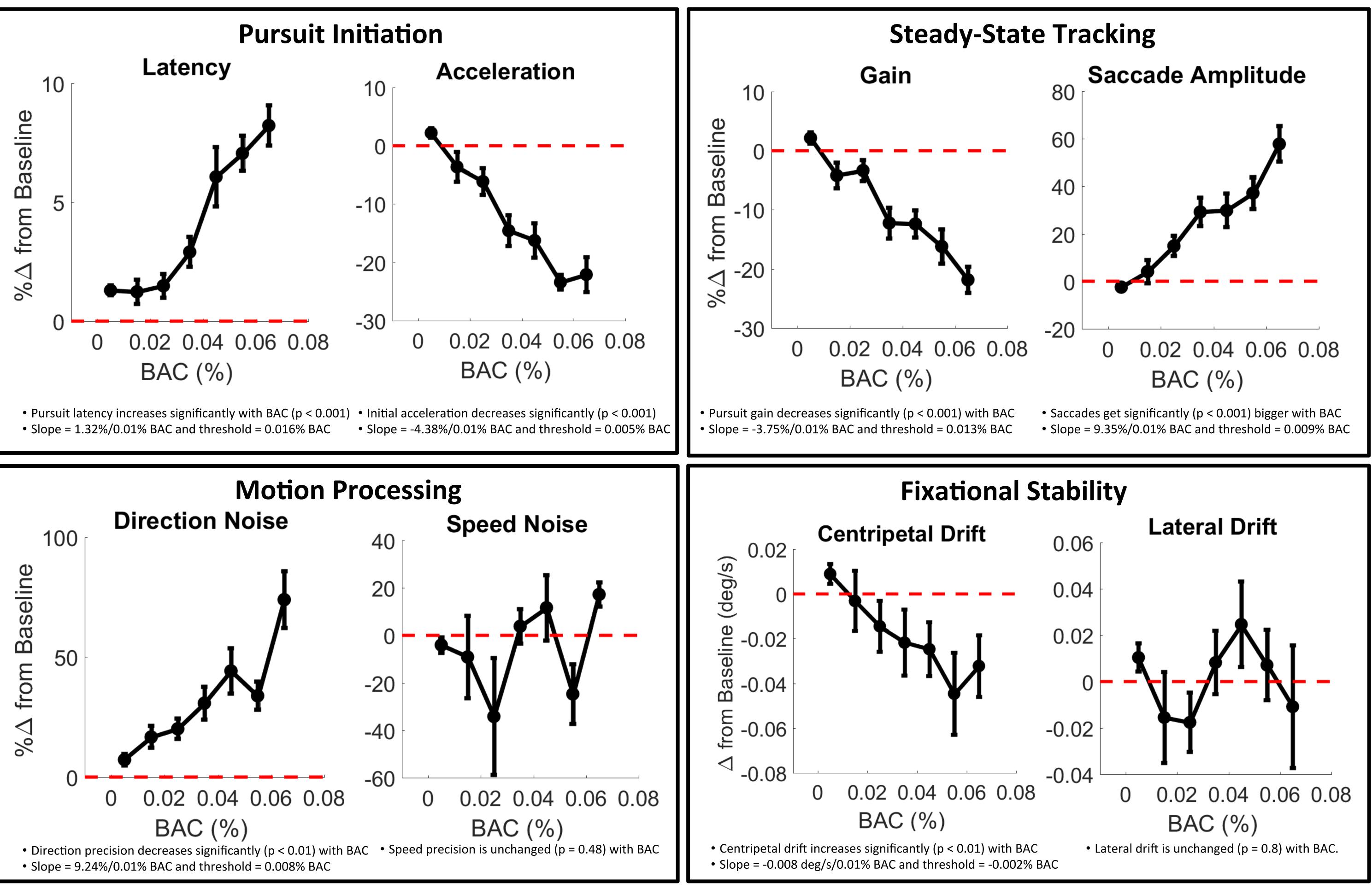
Previous studies have shown that some features of oculomotor performance are impaired at or slightly below the driving legal limit of most U.S. States (0.08%) BAC). Specifically, alcohol impairs saccade latency (Moser et al., 1998; Roche & King, 2010), saccadic velocity (Fransson et al., 2010; Roche & King, 2010), and steady-state tracking (Fransson et al., 2010; Moser et al., 1998; Roche & King, 2010) at levels between 0.04% and 0.1% BAC. Here we used a suite of standardized oculometric measures (see Liston & Stone, 2014) to examine the effect of low levels of alcohol (down to 0.01% BAC) to assess the impact on dynamic visual processing and oculomotor control (Stone & Krauzlis, 2003; Krukowski & Stone, 2005; Stone et al., 2009). We found that very low levels of alcohol generate significant impairment in visual motion processing and pursuit.

METHODS

- 13 healthy participants (8 females, mean age + SD = 25.2 + 2.1 years) with normal or corrected-to-normal acuity.
- 3-day at-home pre-study schedule including 8.5 hours in bed at night with regular timing verified by actigraphy, call ins, and sleep logs.
- 2-day laboratory study where subjects consumed a single low-dose of ethanol (40% ABV Vodka mixed with juice), with three pre-dose and 6-9 post-dose oculomotor testing sessions using a 5-minute Rashbasslike ocular tracking task (Krukowski & Stone, 2005).
- Subjects were asked to track radial step-ramp motion of a small spot in a random direction (90 trials sampling directions around the full circle every 4°) with randomized fixation duration (i.e., target motion onset) thus generating large spatial, directional, and temporal uncertainty in the stimulus trajectory.
- We computed 21 largely independent measures of oculomotor performance, plotted mean±SEM across subjects, and used linear regression to quantify the slope and threshold of any deviation from baseline.

¹San José State University Research Foundation, ²NASA Ames Research Center, Human Systems Integration Division RESULTS





CONCLUSIONS

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Visuomotor performance is significantly impaired in a dose-dependent manner at BAC levels starting as low as 0.01%, which is 8-times lower than the legal limit for operating a motor vehicle in most States. For most metrics of pursuit, saccades, fixation, and visual motion processing, performance deficits increase quasi-linearly by between 1.3% and 9.4% for each 0.01% increase in BAC.

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