The many factors affecting near-collision driver response
A simulator study and a computational model
Gustav Markkula1, Johan Lodin2, Peter Wells2, Mathias Theander2, Jesper Sandin3

1 Institute for Transport Studies, University of Leeds, 2 Volvo Group Trucks Technology, Advanced Technology and Research, 3 Swedish National Road and Transport Research Institute

Background
Need to understand and model driver response in critical situations:
• Improved algorithms for active safety (AS) and automated driving (AD)
• For example, out of FCW
• Warnings and control interventions from AS/AD

Factors that might affect driver response
Scenario kinematics  Driver expectancy  Driver experience, age, state, ...
Warnings and control interventions from AS/AD
Prior driver experience of warnings/interventions from AS/AD

Research questions
• Benefit of warning in unexpected scenario only with prior system experience?
• Do AS brake interventions affect driver tendency to apply steering avoidance?
• Can accumulator models be used to model when drivers start responding?

Simulator study
Volvo Trucks on-market Advanced Emergency Braking System (AEBS)

Simulated motorway driving in moving-base simulator (VTI Sim IV)

46 professional truck drivers, half of which had worked in Volvo trucks with AEBS and had experience of the forward collision warning (FCW)

Independent variables:
• FCW experience: yes / no (between-subjects)
• AEBS state: FCW + pre-brake / FCW only / Off (between-subjects)
• Scenario: WeakLooming / StrongLooming / WeakLoomingRepeated (within-subjects)

Scenario sequence over 20-25 min driving at 90 km/h:

Critical rear-end scenarios at two levels of kinematical urgency, triggered after a visual-manual secondary task. Interspersed by non-critical / nuisance FCW scenarios to avoid direct brake response to FCW (cf. [1])

Experimental setup:

Full brake
FCW
Pre-brakeDistance alert

FCW on

Pre-brake

Response time distribution

Expects brake response in real crashes and near-crashes [7]:
Here, by maximum-likelihood fitting of such a model we find that distributions of ART can be well explained across experimental conditions by assuming:
• Noisy accumulator driven by looming (e.g. by $r^{-2}; K = 3.8; \gamma = 0.255\bar{S}$)
• Faster accumulation when scenario is expected ($M = -0.33$ instead of $M = 0$)
• Warning causes initial boost of activation ($\Delta(y) = 0 = 0.4$)

Non-significant (but interesting?) trends

Non-significant interaction, brake response in unexpecteded scenario: FCW useful only for FCW-experienced drivers, even detrimental for the rest?

Tendency for later steering avoidance among drivers who were given a brake intervention (StrongLooming scenario)

Conclusions
• Replication of effects on ART of (1) kinematics/looming, (2) scenario repetition, (3) FCW
• Accumulation model can nicely explain observed distributions of ART across these conditions
• Non-significant trends align with hypotheses about effects of prior FCW experience and brake interventions

Key references

Replicated findings for accelerator release

• Shorter accelerator release time (ART) in repeated scenario
• Shorter ART with FCW
• Shorter ART in more kinematically urgent scenario

(See e.g. [1, 2, 3])

Computational modelling of accelerator release time

There is much support from neuroscience and psychology for evidence accumulation (or drift diffusion) models of perceptual decision-making [4, 5]

...