The many factors affecting near-collision driver response
A simulator study and a computational model

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Background

Need to **understand and model driver response in critical situations**:

- Improved algorithms for active safety (AS) and automated driving (AD) (For example transitions out of AD)
- Virtual testing of AS and AD

Factors that might affect driver response

Scenario kinematics   Driver expectancy   Driver experience, age, state, ...

Warnings and control interventions from AS/AD

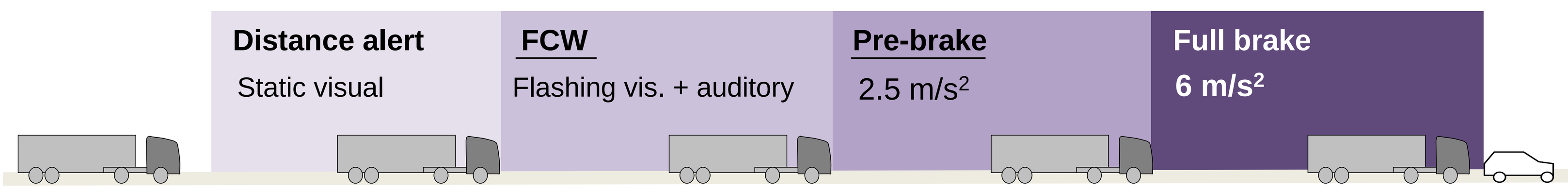
Prior driver experience of warnings/interventions from AS/AD

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)

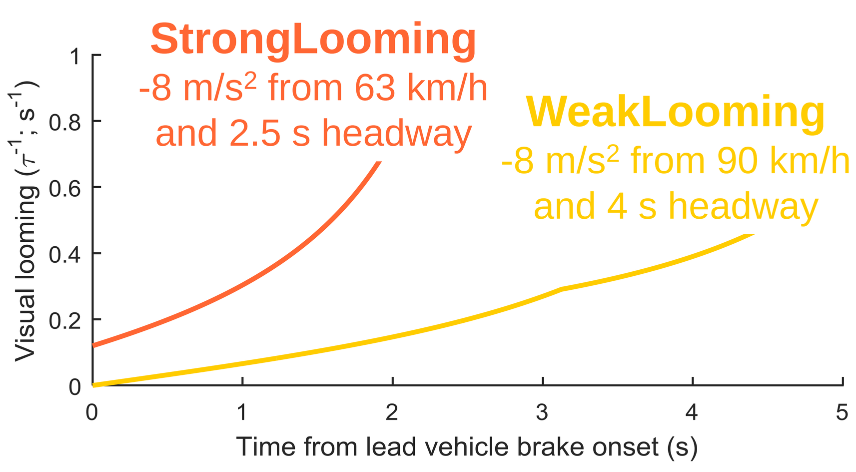
Independent variables:

- 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.**

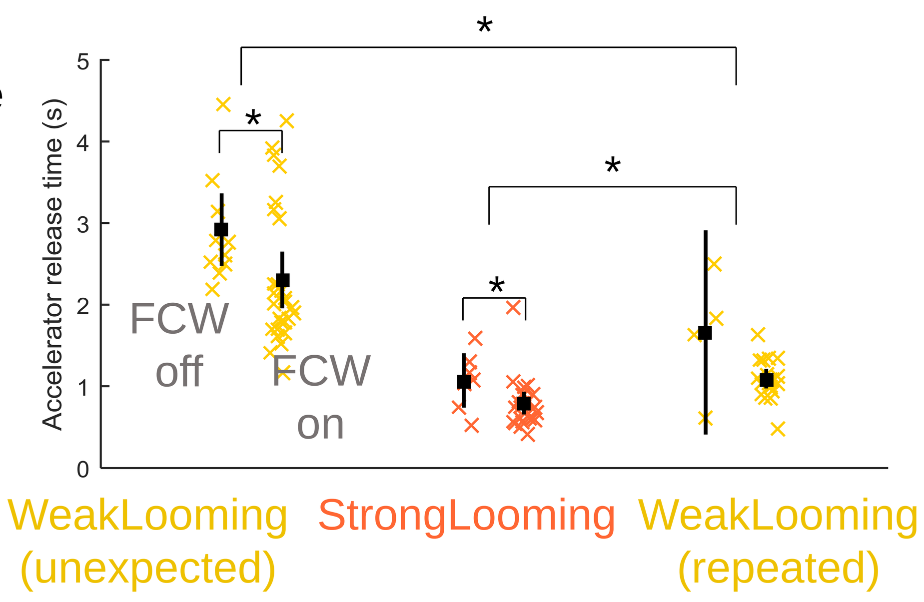
Interspersed by **non-critical / nuisance FCW scenarios** to avoid direct brake response to FCW (cf. [1])



Replicated findings for accelerator release

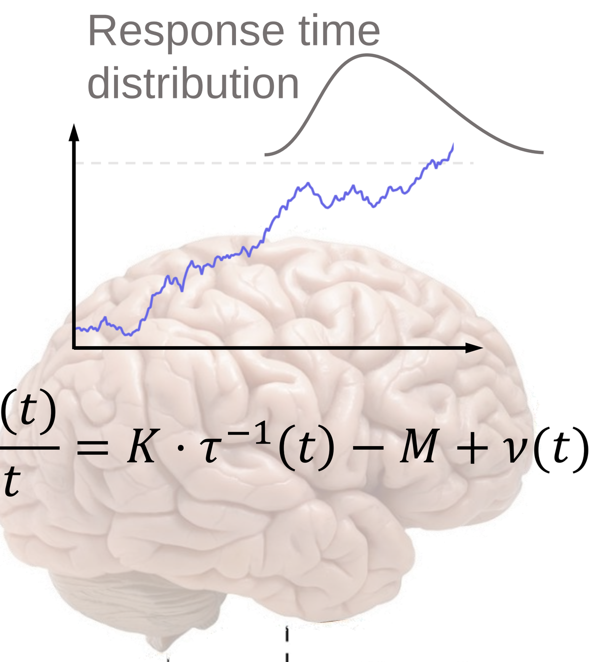
- Shorter accelerator release time (ART) in repeated scenario
- Shorter ART with FCW
- Shorter ART in more kinematically urgent scenario

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

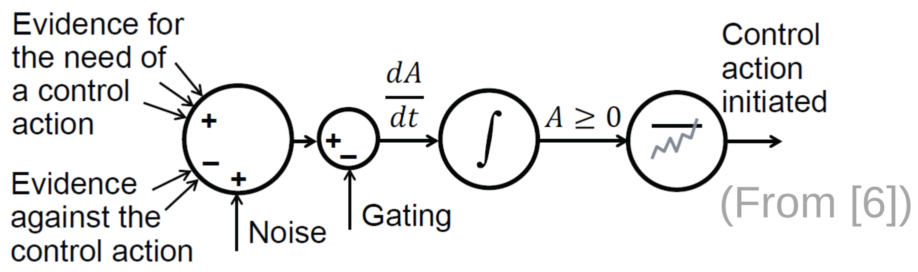


Computational modelling of accelerator release time

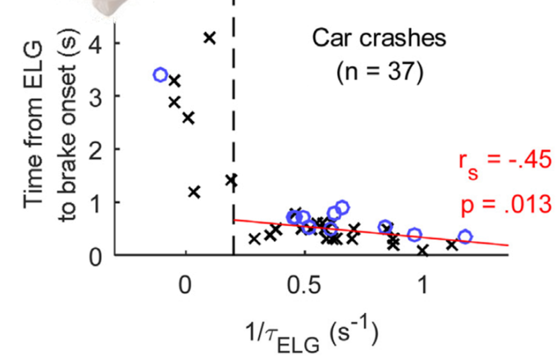
There is much support from neuroscience and psychology for **evidence accumulation** (or drift diffusion) models of perceptual decision-making [4, 5]



$$\frac{dA(t)}{dt} = K \cdot \tau^{-1}(t) - M + v(t)$$

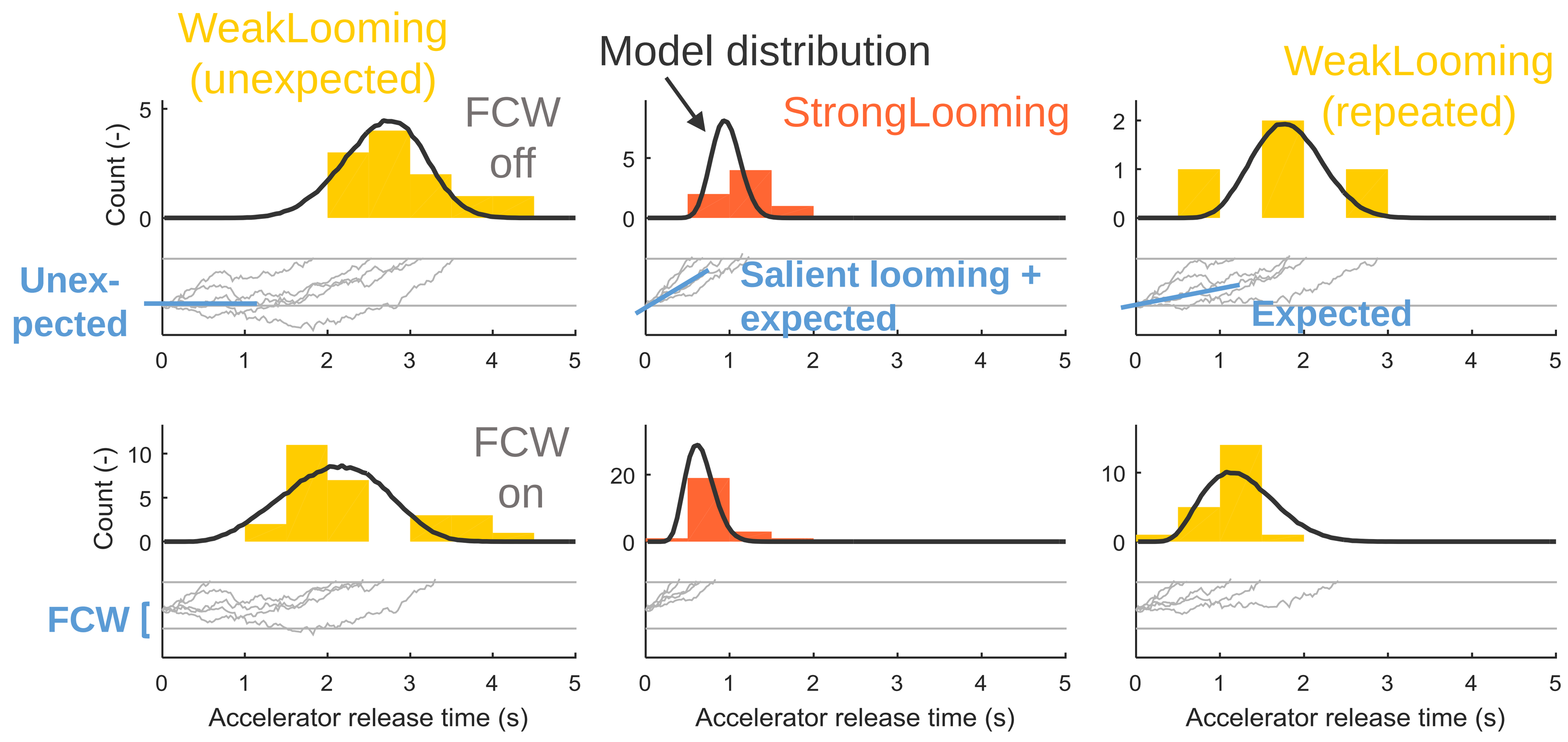


Explains brake response in real crashes and near-crashes [7]:

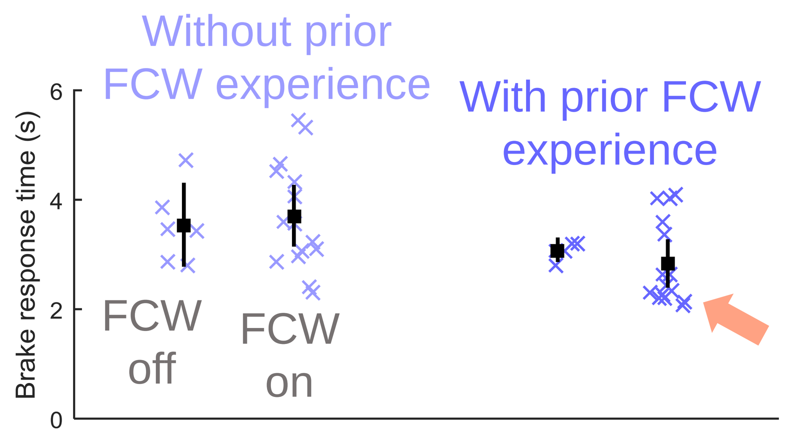


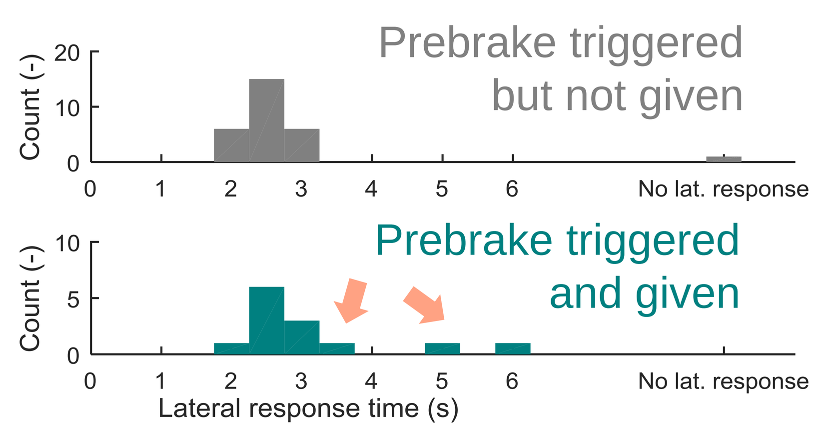
Here, by maximum-likelihood fitting of such a model we find that **distributions of ART** can be well explained **across experimental conditions** by assuming:

- Noisy accumulator driven by looming (e.g. by τ^{-1}; $K = 3.8$; $v = 0.25\sqrt{\Delta t}$)
- Faster accumulation when scenario is expected ($M = -0.33$ instead of $M = 0$)
- Warning causes initial boost of activation ($A(t = 0) = 0.4$)



Non-significant (but interesting?) trends





Non-significant interaction, brake response in unexpected 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

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[6] Markkula, G. (2014). Modeling driver control behavior in both routine and near-accident driving. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 58, pp. 879–883). Chicago, IL.

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