Preventing mind-wandering during driving

Predictions on potential interventions using a cognitive model

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Introduction

In this study, we made predictions on the effects of different interventions by assistive systems designed to prevent MW while driving. Among others, Nijboer and colleagues[1] have shown that a simple secondary task can improve driving performance when the driving scenario is mundane. The authors hypothesized that if the driving task is simple, people might start mind-wandering (MW), which interferes with driving. To test the effect of different interventions to prevent MW on driving performance, we combined three ACT-R models that have been tested in isolation: a driving model[16], a MW model[13] and a listening model[17] for a total of six models.

Theoretical assumptions

We derived 4 core assumptions from the empirical literature:

1. MW while driving has a negative effect on driving performance by lowering the (visual) attentional involvement in the driving task[2, 3, 4, 5, 6]
2. The effects of MW seem reversible when a minor additional task is introduced[1, 7, 8, 9] or when the driving situation becomes more demanding[10, 11, 12]
3. MW seems to be functionally and behaviorally different from regular secondary tasks and cannot be adequately simulated by models of multitasking[8, 13, 14, 15]
4. MW appears to induce periods, in which no substantial updates are made to the main task[13, 15, 12]

Highlights

- Simple tasks may prevent MW during driving and induce less cognitive load than MW itself
- Interventions to prevent MW while driving incur different processing costs
- Maintaining a certain amount of load may outperform adaptive systems

Intervention models

We induced different amounts of load during specific times and thereby simulated the effects of an assistive system that attempts to improve driving performance by preventing MW. We simulated two continuous load models (*mild load model, intermediate load model*) and two adaptive load models (*warning model, mild load + warning model*).

continuous models

Model	Load induced during Driving	Load induced during MW
Driving model	None	None
MW + driving model	None	None
Mild load model	Mild load	Mild load
Intermediate load model	Intermediate load	Intermediate load
Warning model	None	Intermediate load
Mild load + warning model	mild load	Intermediate load

adaptive models

Processing cost

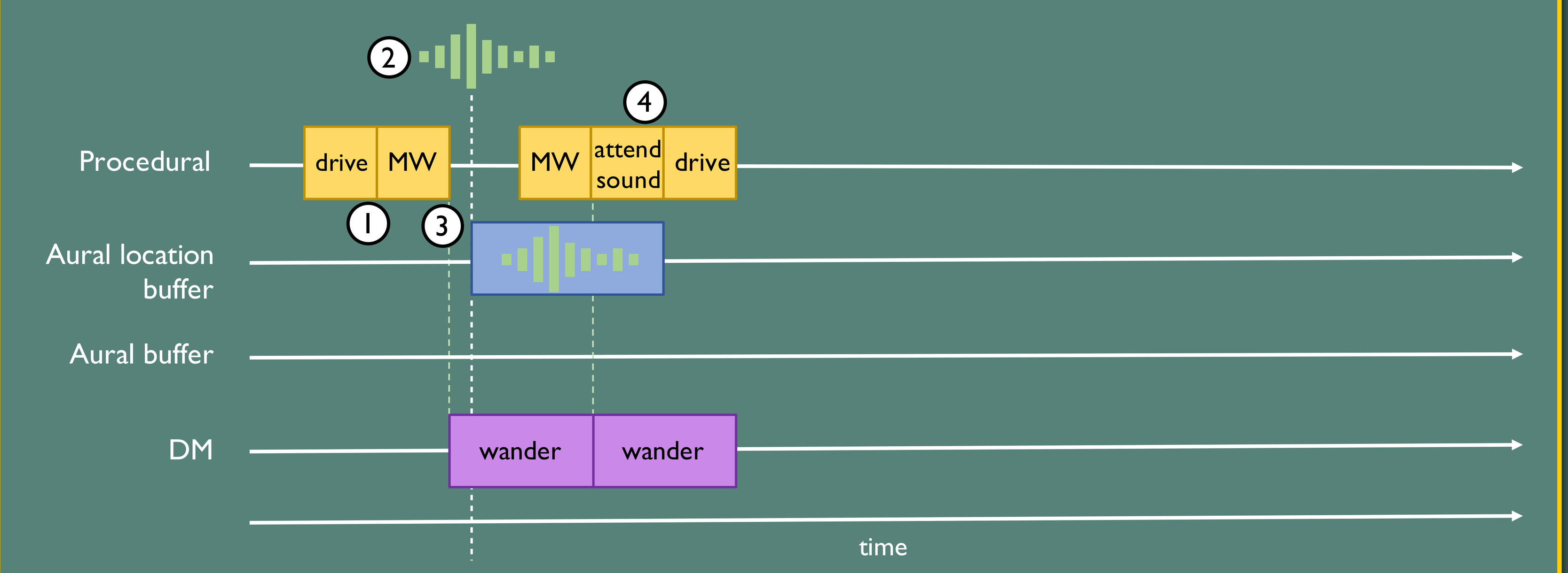
- We calculated the period between attending the stimuli and interrupting MW

Model	Delay
Intermediate load model	0.55s
Warning model	0.78s
Mild load + warning model	0.75s

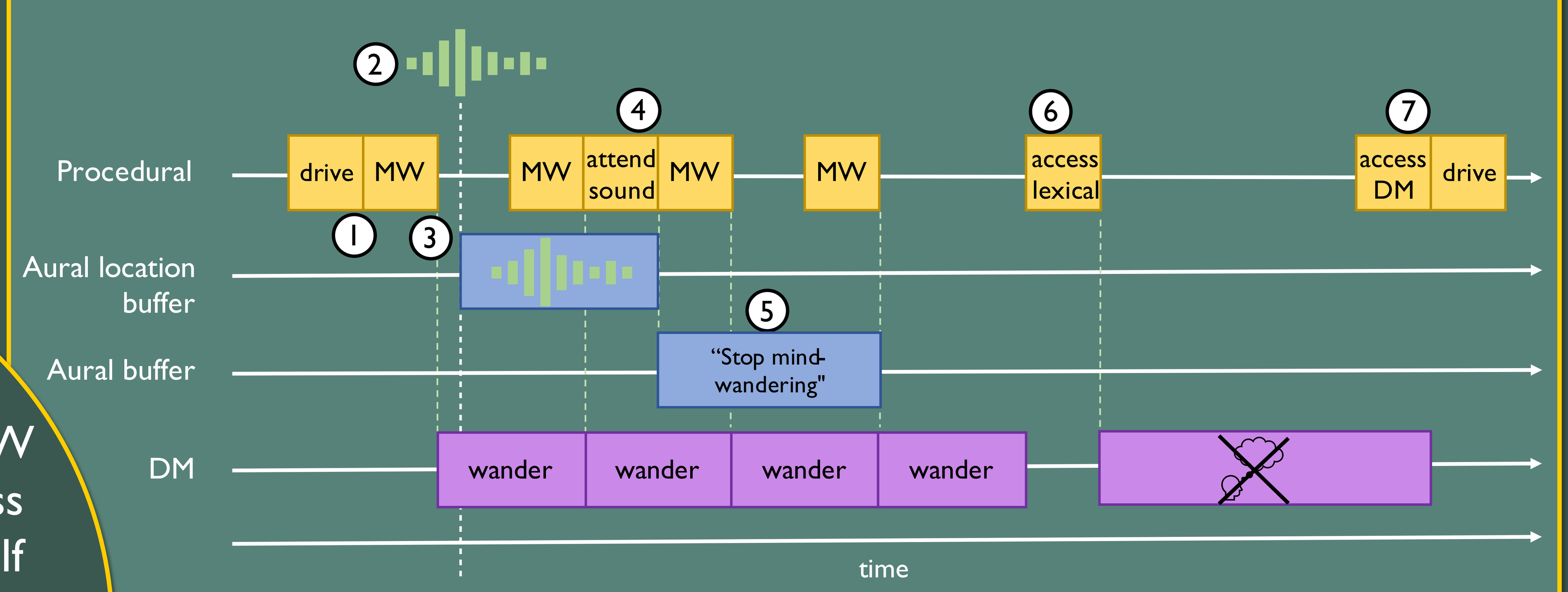
- Surprisingly, adaptive interventions models take a longer time to interrupt MW

Model overview

a) Superficial listening stream employed to process mild load

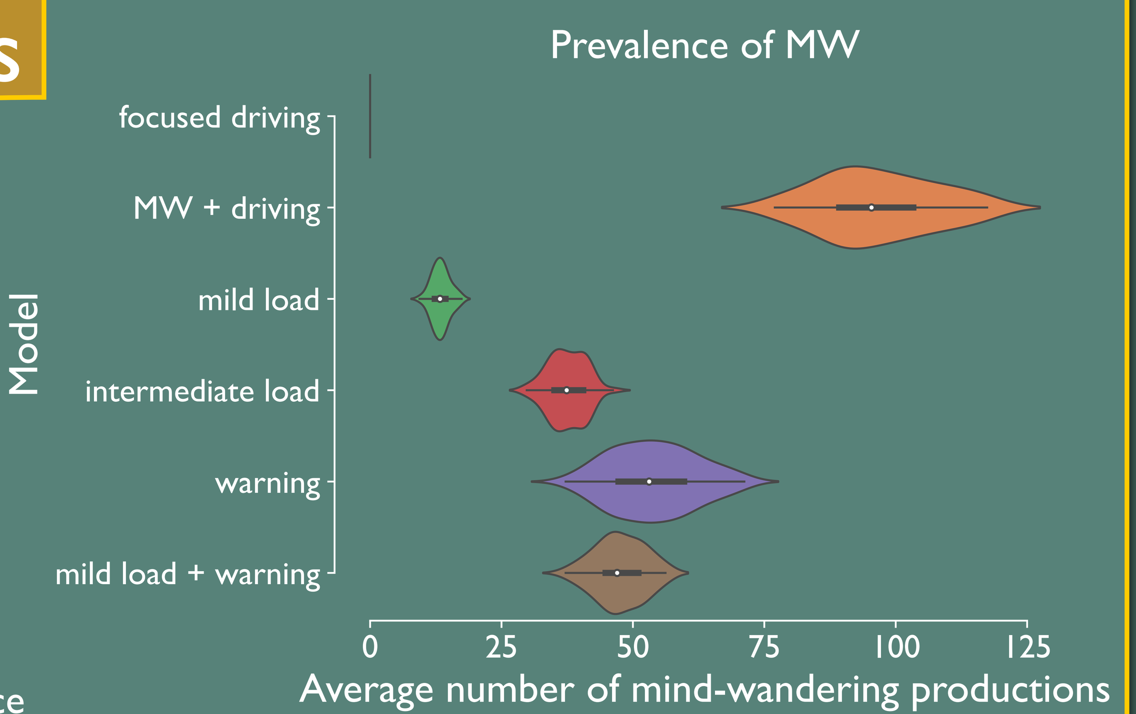


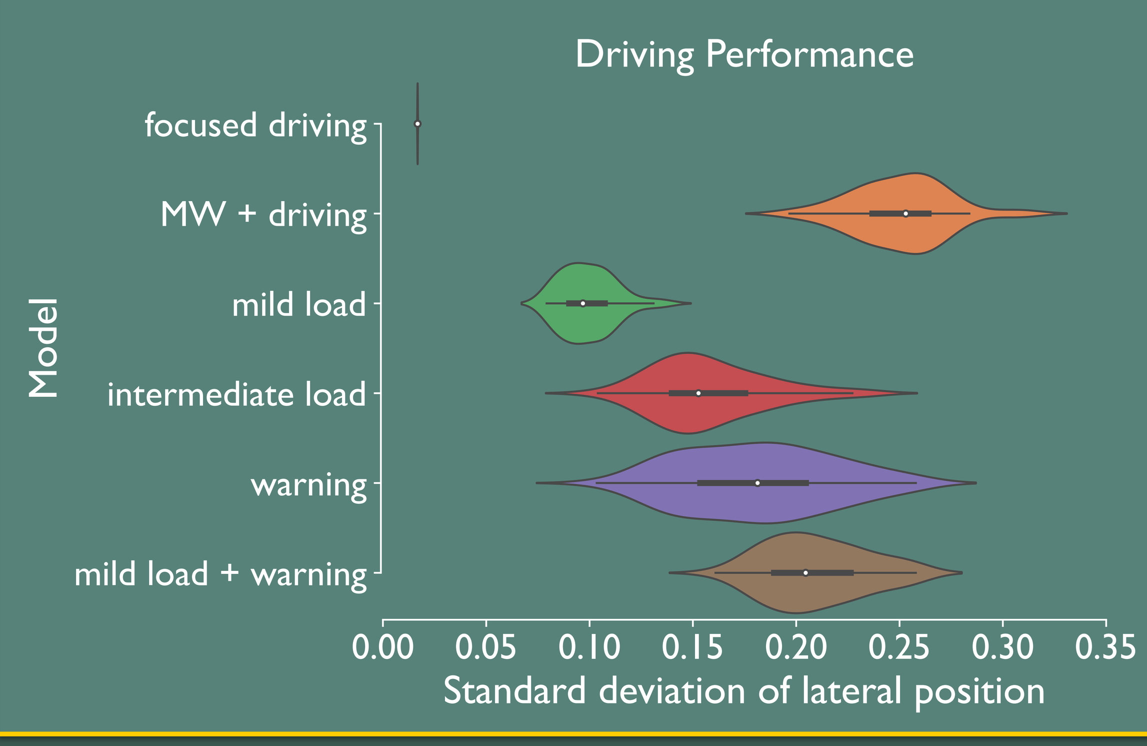
b) Deep processing listening stream warning model employed to process intermediate load



Predictions

- Mild load intervention lowest amount of MW
- Adaptive interventions show higher amount of MW





- Mild load intervention shows the best effect on driving performance
- Adaptive interventions perform worse than continuous interventions
- Mild load + warning model shows the lowest driving performance despite interrupting MW sooner

Discussion

- The MW + driving model shows how driving performance decreases when MW occurs
- The continuous load models show the cost/benefit trade-off of manipulating workload
- The adaptive models show that there may be switching costs to new stimuli, which could suggest that maintaining a certain amount of load may outperform an adaptive system
- These models could be used to inform the design of future automation systems attempting to increase safety by lowering mind-wandering during driving

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