Mind wandering and driving

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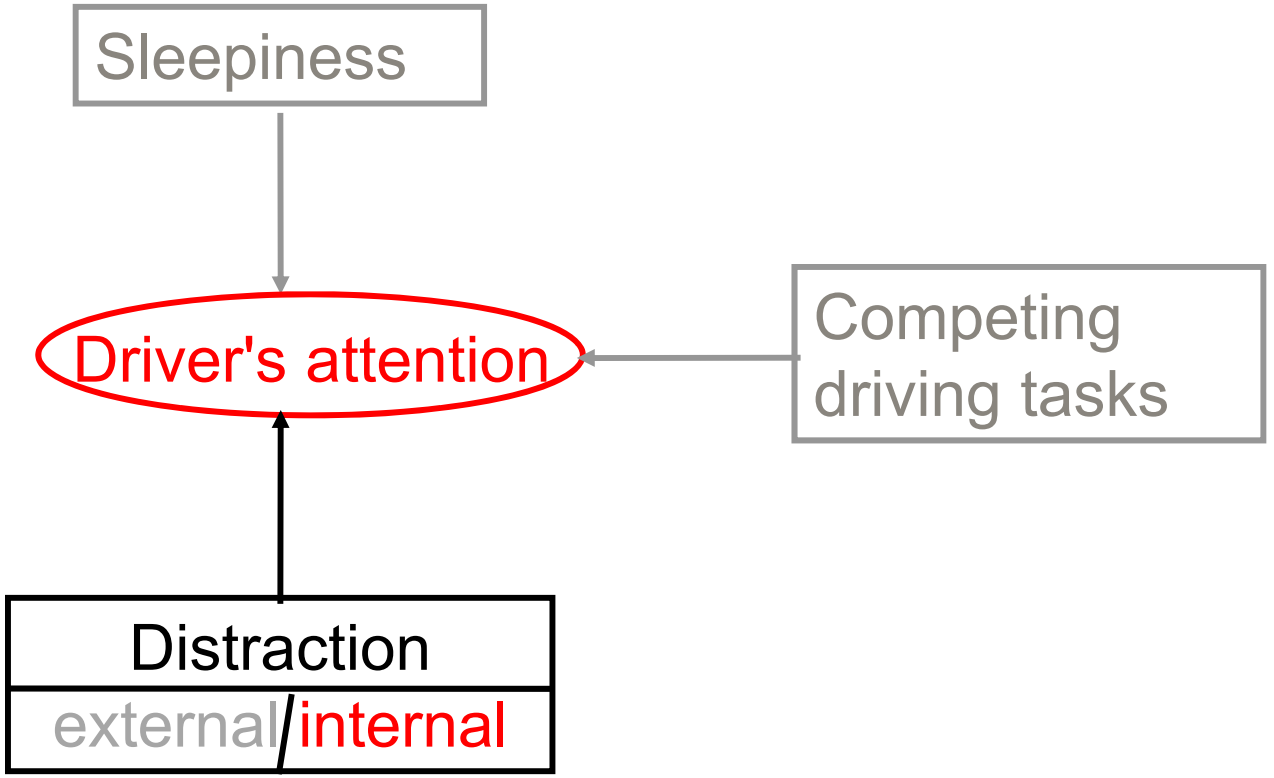
Disruption of attention in drivers



Mind wandering (1)

- Thinking unrelated to the task at hand or to the sensory input
- Activation of the default network (neuroscience)
- Frequent (half of waking life)
- Most often at rest or during repetitive tasks of low cognitive demand
- Adaptive value (learning, autobiographical planning and creativity incubation)
- Maladaptive value (everyday attention failures, depressive mood...)

Mind wandering (2)

- MW could interfere with the driving task

→ **Uncoupling attention from visual and auditory perceptions**

- Propensity for MW variance → population heterogeneity
- Experimental driving simulator studies → MW associated with driving disturbances
- No study in real life context

He et al, Hum Factors, 2011

Driving simulator

Measures of eye movement → when MW: narrower focus of visual attention on the road ahead

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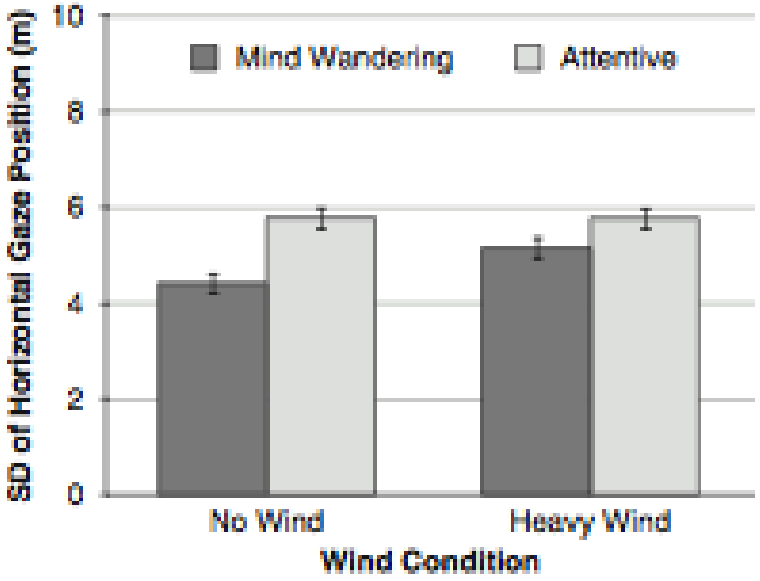
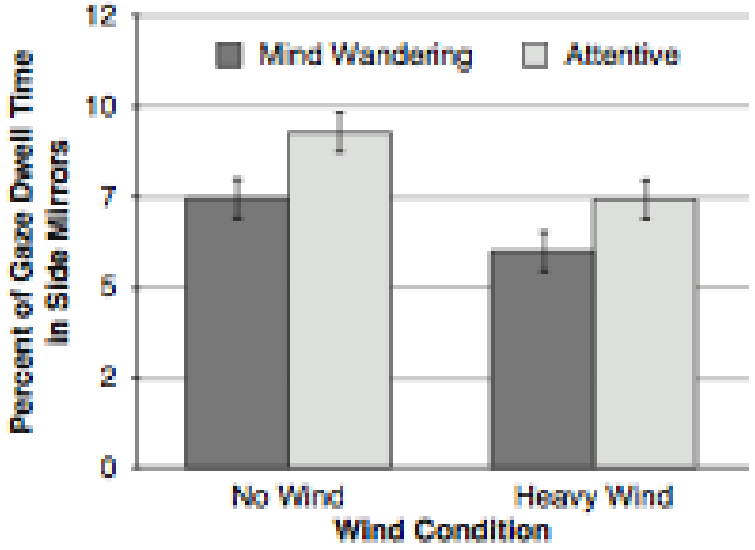
Possible failure to monitor the environment





Measuring being lost in thought: An exploratory driving simulator study

Marieke H. Martens [a,b,*], Rino F.T. Brouwer [a]

Transportation research: F 2013

Internal driver distraction impacted subjective attention scores, higher mean speed, mirror checking = similarly to external driver distraction

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Driving With the Wandering Mind. The Effect That Mind-Wandering Has on Driving Performance

Matthew R. Yanko, Thomas M. Spalek

Hum Factors 2013

When mind-wandering participants showed longer response times to sudden events, drove at a higher velocity, and maintained a shorter headway distance

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Route familiarity breeds inattention: A driving simulator study

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Accid Anal Prev 2013

Familiarity is a source of driving impairment possibly due to increased MW

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- **No study in real life context**

Objective

To assess in real life conditions

the link between mind wandering

and

the risk for being responsible for the crash

Hypothesis

Mind wandering, especially when intense, would increase the risk for being responsible for the crash

Methods: design and setting

- **Responsibility case-control study**
  - Compare the frequency of exposures between drivers responsible for the crash (cases) and drivers not responsible for the crash (controls)
- **Adult emergency department** of the Bordeaux University hospital
- Recruitement from April 2010 to August 2011
- **Direct interviews** by trained interviewers
- Information about the **crash**, **patient characteristics**, and **distraction**

Methods: participants

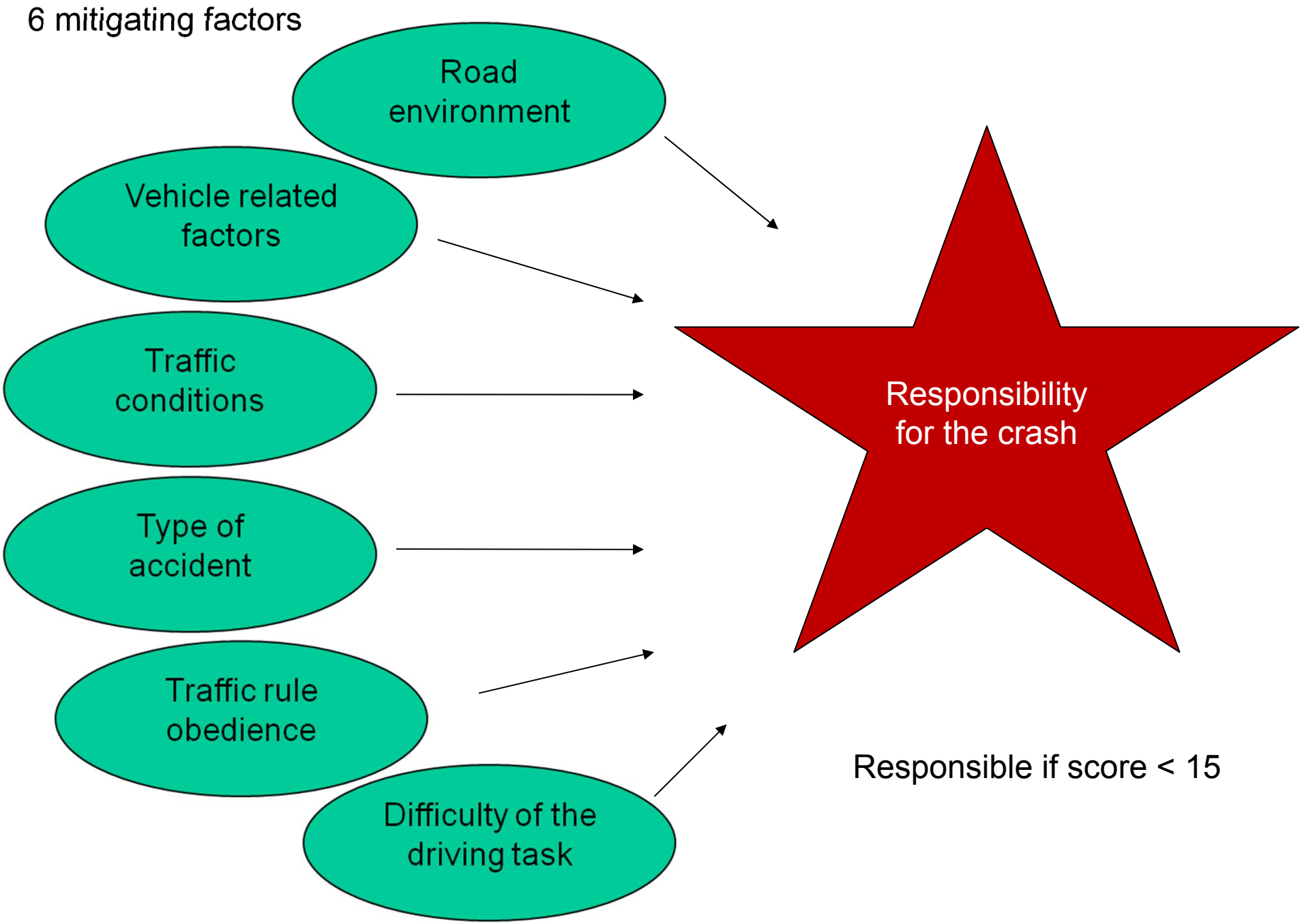
- Eligibility for **study inclusion**
  - Admission to the emergency department in the previous 72 hours
  - Injury linked to a road traffic crash
  - Aged 18 years or older
  - Drivers
  - Ability to answer the interviewer (Glasgow Coma Score = 15)

- 1436 patients assessed for eligibility
  - 309 excluded for ineligibility (not driver n=93; admission for more than 72 hours n=29; unable to answer n=246)
  - 57 refused to participate
  - 56 excluded from the analysis because of incomplete data

- **Final sample** for analysis = **955 patients** (89% of the eligible drivers)

Outcome: responsibility for the crash

- An original investigation tool, specific to road safety
- Method developped by **Robertson and Drummer** (AAP, 1994)
- **Comparing exposure levels between**
  - Drivers responsible for the crash (case group)
  - Drivers not responsible for the crash (control group)
- **Standardized determination of responsibility**
- Adapted **responsibility score**
  - From crash characteristics
  - 6 mitigating dimensions


6 mitigating factors
Road environment
Vehicle related factors
Traffic conditions
Type of accident
Traffic rule obedience
Difficulty of the driving task
Responsibility for the crash
Responsible if score < 15

Main exposure: mind wandering

- Recorded through **verbal reports of thoughts**

- Each thought **classified**
  - Thought unrelated to the driving task or to the sensory input
  - Thought related to the driving task
  - No thought or no memory of any thought

- **Likert-type scale** (0-10) ("How much did the thought disturb you?")
  - Slightly disturbing: 0-4
  - Versus highly disturbing: 5-10

- **Mind wandering variable**
  - MW not reported = reference category
  - MW with little disturbing content
  - MW with highly disturbing content

Other exposures

- **Patient characteristics** (age, gender, socioeconomic category)
- **Crash characteristics** (season, time of the day, location, vehicle type)
- **External distraction** (any external distraction – outside and inside vehicule distractions - versus no external distraction)
- **Affect** (negative versus positive or neutral)
- **Alcohol use** (blood alcohol values ≥ 0.50 g/L versus < 0.50 g/L)
- **Psychotropic medicine use** (any use the week preceding the crash versus no use)
- **Sleep deprivation** (< 6 hours versus ≥ 6 hours)

Methods: analyses

- **Sample description**
- **Multivariable model** to evaluate the association between responsibility and exposures (logistic regression)
- Estimation of **attributable fractions** (bootstrap methods)
- **Sensitivity analyses** (modification of the cutpoint value for responsibility)

Sample characteristics of drivers and responsibility

	%Responsible (43)	%Not responsible (57)	N 955
Gender			
-Male	63	59	580
-Female	37	41	375
Age			
-18-24	26	22	226
-25-34	26	26	249
-35-44	15	21	174
-45-54	15	15	147
->55	17	16	159
Vehicle type			
-Light vehicle	47	52	471
-Commercial vehicle	2	2	19
-Heavy goods vehicle	2	1	13
-Bicycle	21	18	188
-Scooter	12	12	114
-Motorbike	16	15	150

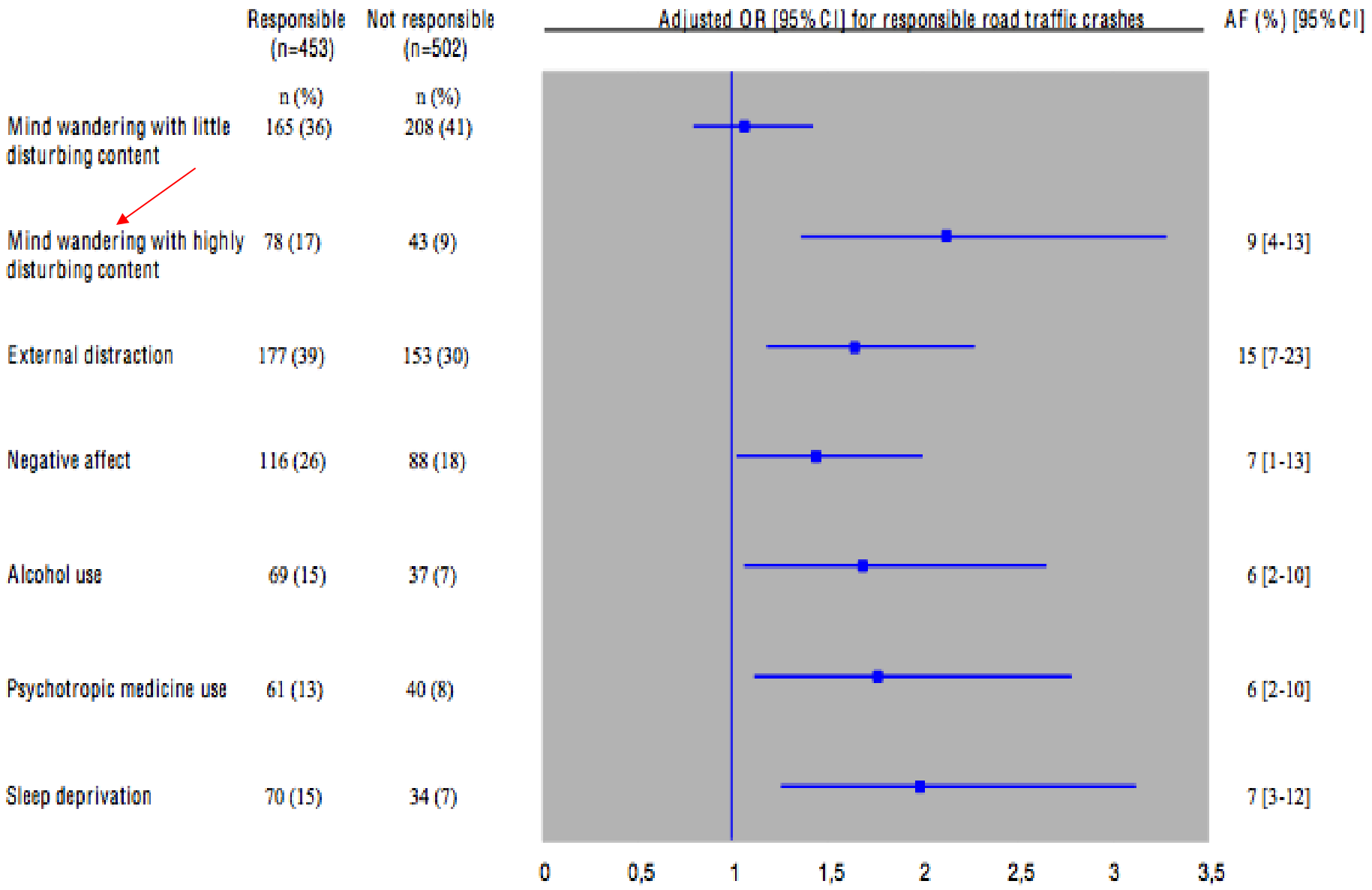
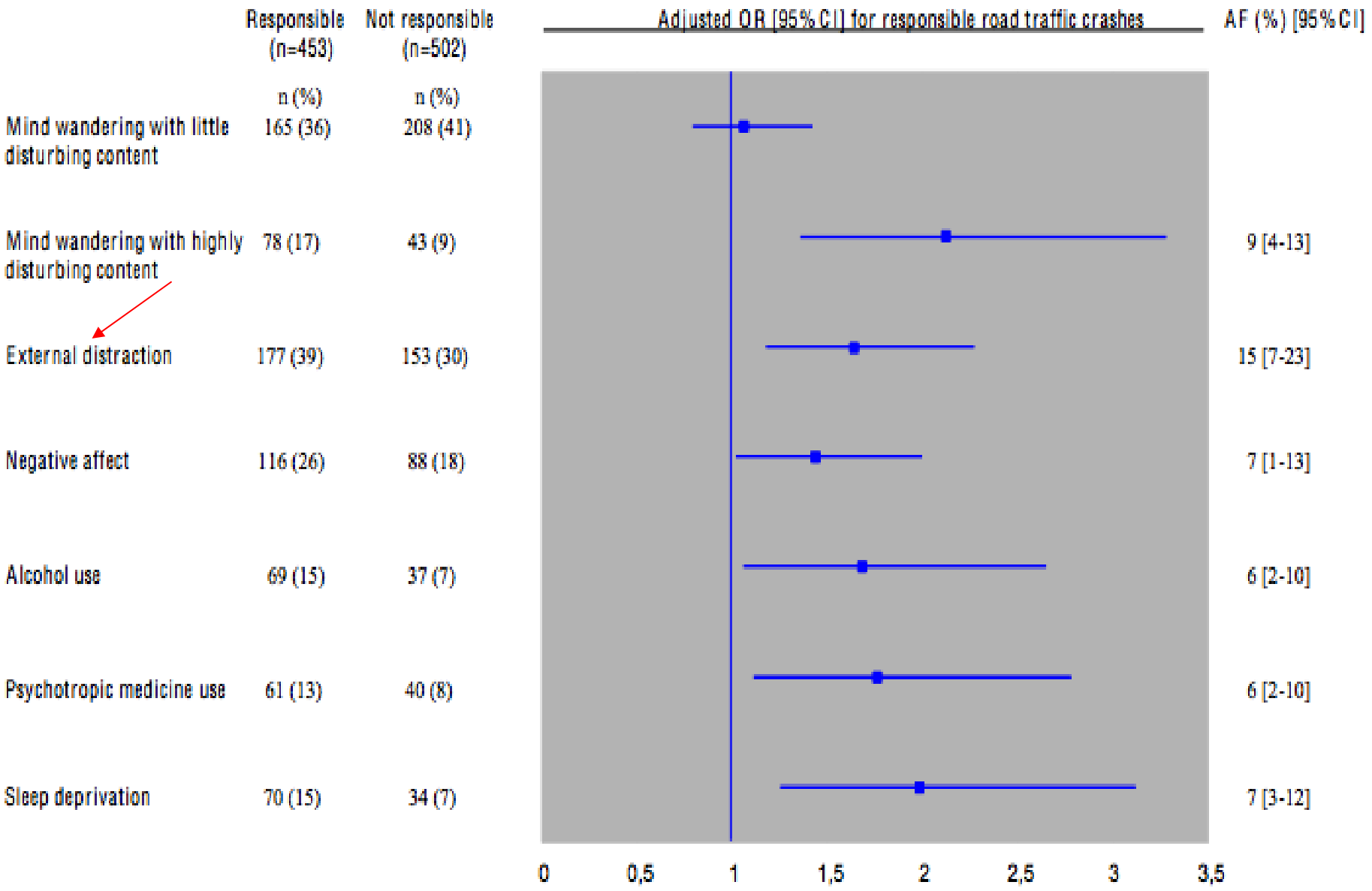


Figure 1. Odds ratios (OR) and attributable fractions (AF) for responsible road traffic crashes, adjusted for age, gender, season, vehicle type, location. Mind wandering: 1.with little disturbing content versus not reported and 2.with highly disturbing content versus not reported. External distraction: any external distraction versus no external distraction. Affect: negative versus positive or neutral. Alcohol use: blood alcohol values ≥ 0.50 g/L versus < 0.50 g/L. Psychotropic medicine use: any use the week preceding the crash versus no use. Sleep deprivation: < 6 hours versus ≥ 6 hours.



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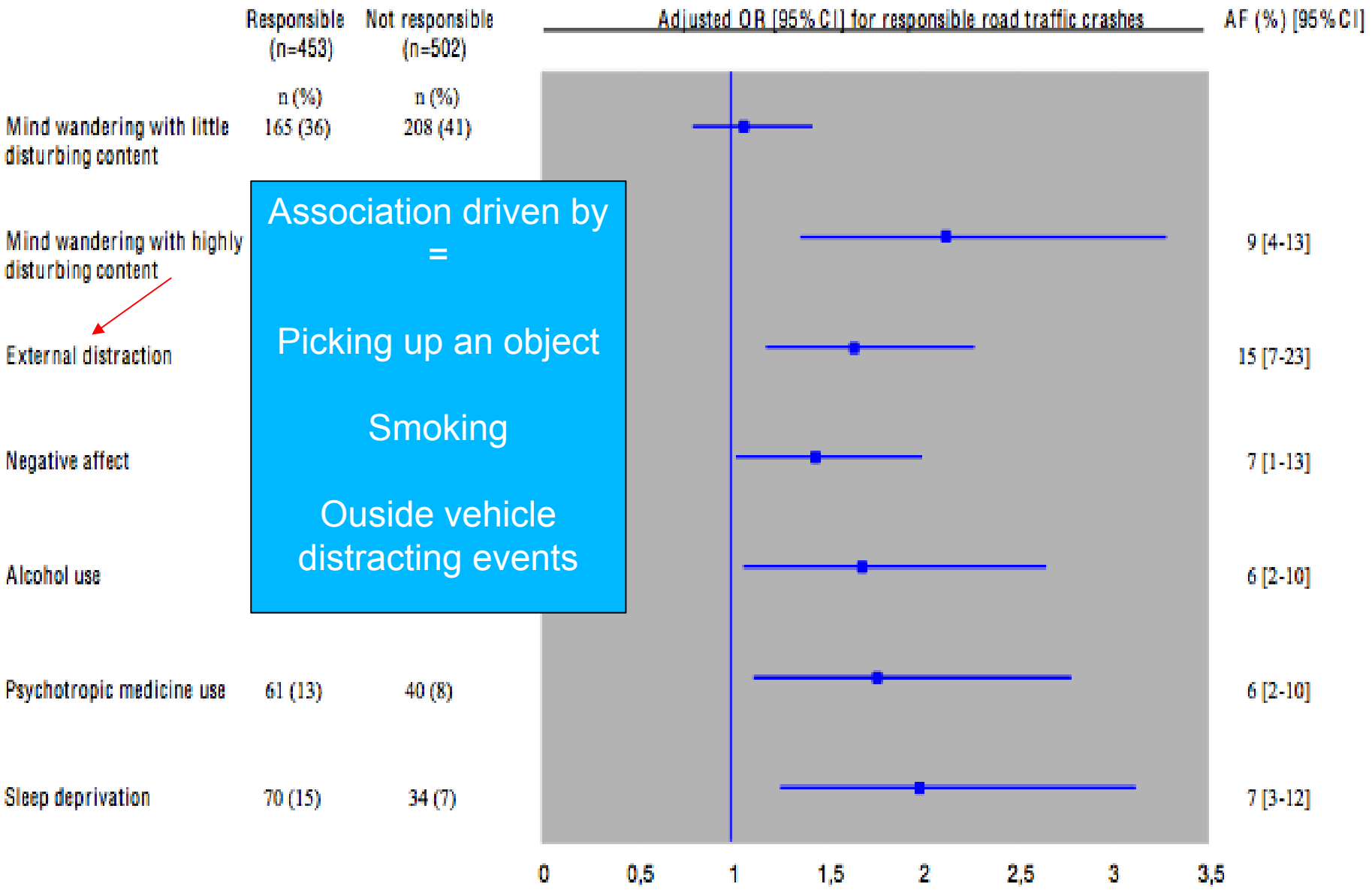

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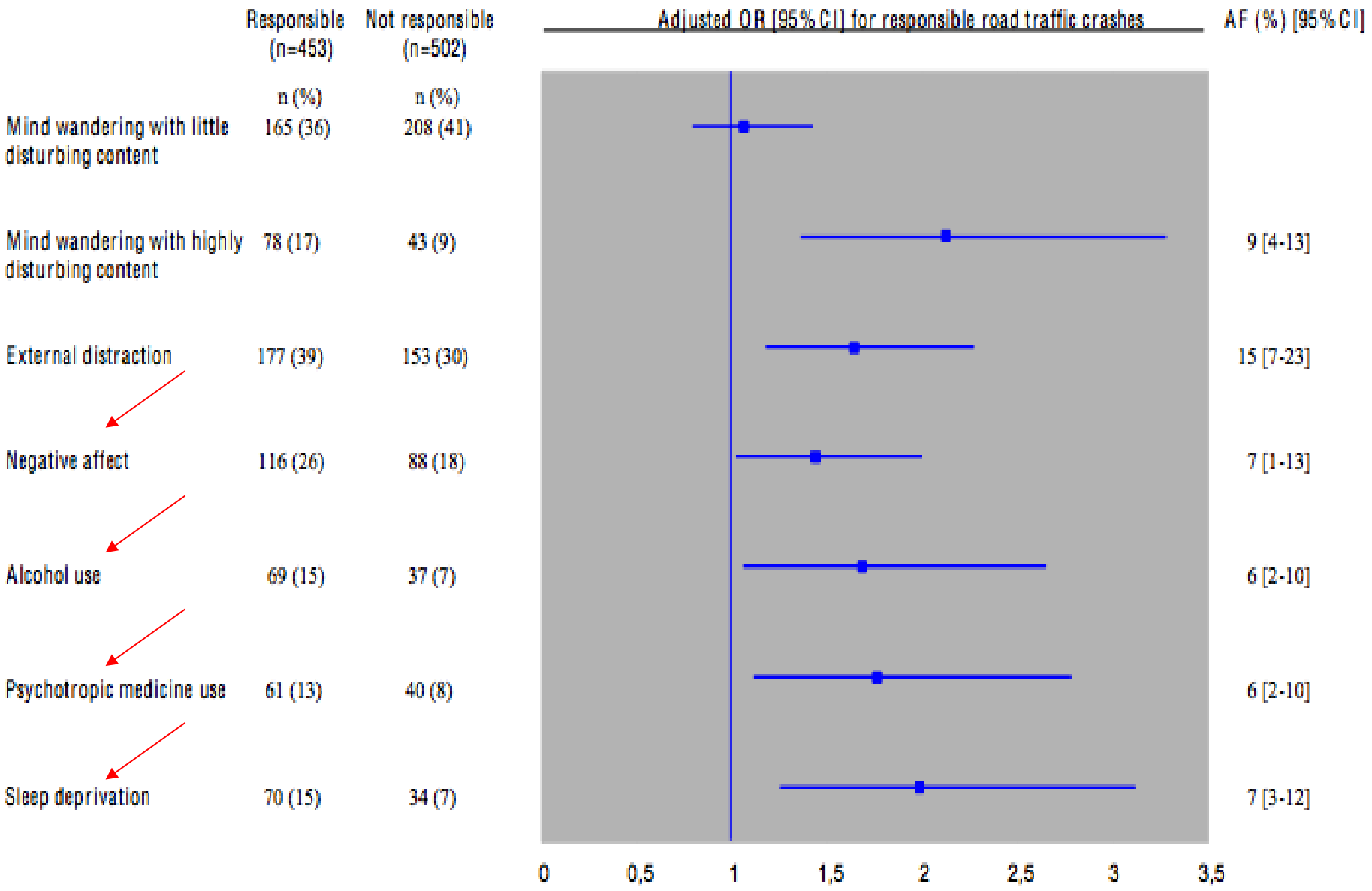

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Discussion: main result

- **Intense MW was associated with being responsible for a crash**
- **17%** responsible vs. **9%** not responsible
- Adjusted **OR [95% CI] = 2.12 [1.37-3.28]**
- **AF = 9%** of all crashes
- Statistically significant after **adjustment for external distraction and a range of potential confounders**

Discussion: interpretation

- **Risky uncoupling of attention from online perception**

→ makes the driver prone to overlook unnoticed hazards and to more errors during driving

- Compendium of studies **linking MW to attention failures**
  - Neuroimaging
  - Electrophysiological
  - Neuropsychological

Neuroimaging research

Christoff, PNAS, 2009
Christoff, BR, 2011

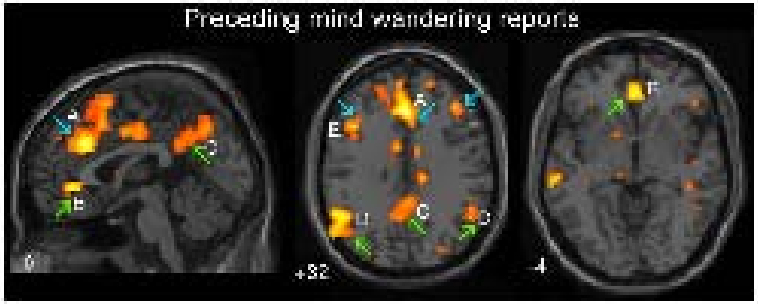

Fig. 2. Activations preceding reports of mind wandering (intervals prior to off-task versus on-task probes). Upward green arrows, default network regions; downward blue arrows, executive network regions. Regions of activation included: (A) dorsal ACC (BA 32), (B) ventral ACC (BA 24/32), (C) precuneus (BA 7), (D) bilateral temporoparietal junction (BA 39), and (E) bilateral DLPFC (BA 9). Height threshold $P < 0.005$, extent threshold $k > 5$ voxels.

Functional interactions between large-scale brain networks during MW:

a **positive connectivity** between areas of **executive** and **default networks**
and
a **negative connectivity** between **primary sensory cortices** and **default network**

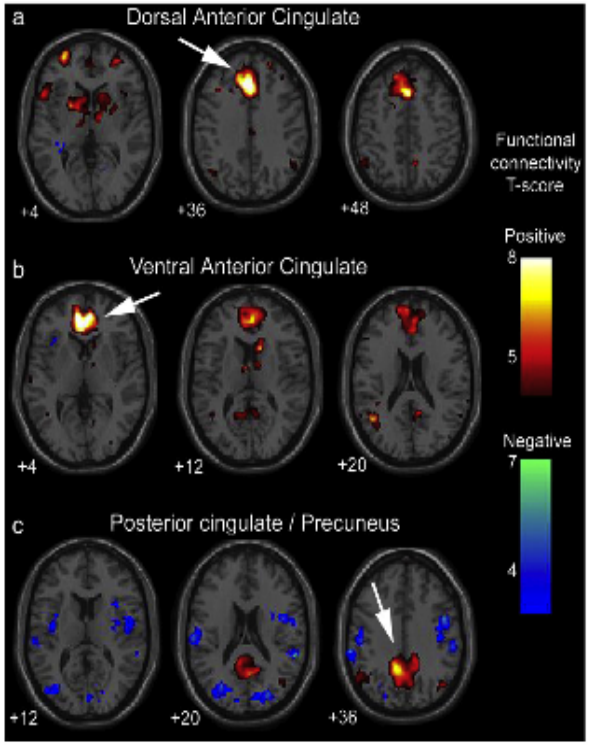

Fig. 2 – Functional connectivity of the dorsal anterior cingulate (dACC), ventral anterior cingulate (vACC), and posterior cingulate (PCC)/precuneus region during mind wandering. The arrows point toward the approximate location of the seed regions' peaks (dACC, x, y, z = 0, 30, 32; vACC, x, z, z = 2, 40, −4; and PCC/precuneus, x, y, z = −6, −52, 40). (a) dACC showed positive functional correlation with bilateral rostrolateral prefrontal cortex (BA10), bilateral inferior frontal cortex (BA45/48), the PCC (BA 23/31), left posterior parietal cortex (BA39/40), bilateral caudate/putamen and the cerebellum. (b) vACC showed positive functional correlations with the adjacent dACC (BA24/32/9), the superior temporal cortex (BA39), the PCC (BA23/31), the caudate and the thalamus. (c) PCC demonstrated positive functional correlations with the adjacent precuneus (BA23/31/7) and bilateral superior temporal cortex (BA39); it was inversely correlated with the primary motor and somatosensory cortices (BA4/2/3), the extrastriate visual cortex (BA19) and bilateral insula. Height threshold P < 0.005 uncorrected.

Discussion: interpretation

- **Electro-encephalographic (EEG) studies** (Christoff, 2011)

  → Reduced cortical analysis of sensory visual and auditory inputs during mind wandering

- **Neuropsychological studies** (Smilek, 2010 ; Smallwood, 2011)

  → Eye-tracking and electro-oculography

  → Increased eye blinking

  Less complex eye movements

  Modifications in pupil diameter (reduced transient responses to task events and enhanced baseline levels)

Discussion: limitations

- Retrospective self-reports
- Incomplete recall
- Desirability bias
- Cross-sectional study
- Temporal sequence of exposures and road crash
- Responsibility method ?

Discussion: intervention perspectives

- **Inside-vehicle technologies**

→ Use driver behaviour (eye movement, driving performance...)

→ To detect inattention

→ To provide immediate feedback to redirect attention to the roadway and enhance proper scanning of the environment

- **Attentional training in problematic mind wanderers**

→ Identification of high-level mind wanderers through post-drive feedback of natural or driving simulator conditions

→ To increase awareness of thoughts and attention to the road

References :
Galéra et al. Mind-Wandering and driving. Results from a case-control responsibility study. BMJ 2012. 345:e8105.

Bakiri et al. Distraction and driving: Results from a case-control responsibility study of trafic crash injured drivers interviewed at the emergency room. Acc Anal Prev. 2013. 59C:588-592.