Outcome Evaluation of i-DREAMS (H2020 Project) Interventions: Multi-Country Comparison of Driving Behvavior

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Introduction

The i-DREAMS project (https://idreamsproject.eu/wp/) introduced the **'Safety Tolerance Zone'** (STZ) concept, a context-aware safety envelope designed to prevent unsafe driving by providing real-time and post-trip interventions.

- In-vehicle interventions inform or warn drivers in real-time to avoid potential dangers (nudging)
- Post-trip interventions inform drivers after driving through an app-based gamified coaching platform to improve driving behaviour (boosting)

This study focuses on the outcome (or effectiveness) evaluation of the i-DREAMS (H2020 Project) interventions using multi-country comparison analysis of driving performance in the UK, Belgium and Germany.

Research Questions and Hypotheses

Research Question 1
Do real-time and post-trip interventions of the i-DREAMS project make driving safer across different phases of the field trials?

Research Question 2
Do cross-country differences exist in the effectiveness of real-time and post-trip interventions of the i-DREAMS project considering naturalistic data from the UK, Belgium, and Germany?

Based on these research questions, the following hypotheses were tested:

Hypothesis 1
There is no significant difference in the effectiveness of the i-DREAMS interventions across different phases of the field trials.

Hypothesis 2
There is no significant difference in the effectiveness of the i-DREAMS interventions across the UK, Belgium, and Germany

Method

Longitudinal field operational test

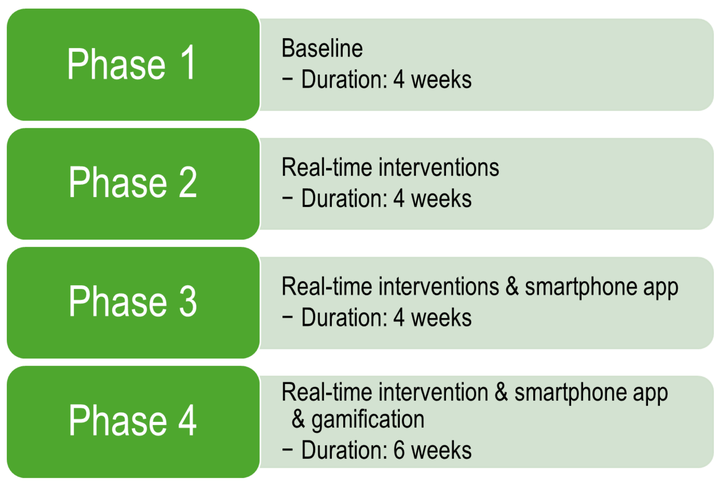

Figure 1 Intervention phases of the i-DREAMS project

Naturalistic driving data collected concerns a variety of data about:

- Safety promoting goals (SPG)
- Performance objectives (PO)

Table 1 SPG, PO and their interrelationship.

Safety Promoting Goals (SPG)	Performance Objectives (PO)
Vehicle Control (VC)	Acceleration, Deceleration, Steering Control
Speed Management (S)	Speed
Road Sharing (RS)	Headway, Illegal Overtaking, Lane Discipline, Forward Collision Warning, and Pedestrian Collision Warning
Driver Fitness	Fatigue and Handheld mobile phone use (during driving)

Three stages of STZ:

- Normal Driving (low severity level): No real-time intervention
- Danger (medium severity level): A real-time intervention via an alert
- Avoidable Accident (high severity level): An intrusive warning signal (either or not accompanied by an instruction)

Method (Contd.)

Real-time interventions

- Headway, Speed, Fatigue, Illegal overtaking, Lane departure and Pedestrian collision

Post-trip interventions

- Feedback is given to the driver after driving, with the help of a smartphone applications which also provides gamification elements (e.g. leaderboard, goals, pros and cons for certain driving behaviour).

Sample: 48 Belgian and **49** UK and **25** German car drivers

Analysis

- **Descriptive comparison:** *Changes in number of normalized events (i.e. events/100km) for the two highest risk stages of STZ*
- **Statistical tests:** *Repeated measures ANOVA (if normally distributed), otherwise equivalent non-parametric Friedman test.*
- **Statistical model:** *Generalized Linear Mixed Model (GLMM)*
- Individual driver level analysis to investigate the differences (not detectable in group level analysis).

Results

Total events

- The **UK**'s drivers generated **more** events/100 km
- Consistent reduction pattern over the subsequent intervention phases **for the UK** only
- Investigation further revealed that the **higher number of events** for **UK drivers** is mainly attributed to the **higher number** of trips in **urban areas,** which means higher interactions with other vehicles.

Table 2 Total events/100km with respect to intervention phases

Phase	Belgium (n=48)		UK (n=49)		Germany (n=25)	
	Events/100km*	SD	Events/100km	SD	Events/100km	SD
1	180.8	94.5	275.3	249.6	152.2	153.7
2	185.7	97.5	261.3	223.8	151.0	114.7
3	188.0	107.0	251.0	225.2	137.3	123.6
4	177.2	105.6	240.7	219.2	149.6	126.2

*Events/100km are mentioned as total events occurred for all risk indicators (POs) in danger and avoidable accidents stages of STZ

Safety Promoting Goal Level Effectiveness

- **UK drivers** show improved behaviour in almost **all SPGs**
- **Belgium drivers** show improved behaviour for **RS type events only**.
- **For German drivers**, at this level results seems not very promising.
- Further separation of these events for danger and avoidable accident stages of STZ noted that for **German drivers speeding events/100km** belonging to avoidable accident stage was **decreased consistently** and that **decrease** is also **statistically significant**.
- **To summarise, the i-DREAMS interventions were effective not for all SPGs but for specific SPGs.**

Table 3 Events/100km with respect to intervention phases

SPG	Phase	Belgium (n=48)		UK (n=49)		Germany (n=25)	
		Events/100 km*	p-value	Events/100km	p-value	Events/100km	p-value
VC	1	101.5	0.070	136.7	0.060	96.8	0.691
	2	107.9		131.7		94.1	
	3	109.9		130.7		89.5	
	4	102.7		130.6		97.3	
RS	1	65.4	0.017	119.7	<0.001	N/A	
	2	62.3		113.8			
	3	61.8		106.0			
	4	59.4		96.2			
S	1	13.9	0.122	18.8	<0.001	55.8	0.218
	2	15.5		15.8		56.8	
	3	16.2		14.3		47.9	
	4	15.1		13.9		52.3	

*Events/100km are mentioned as events occurred for all risk indicators (POs in specific SPG) in danger and avoidable accidents stages of STZ

Generalized linear mixed effect models (GLMM)

- Dependent variable = **Events/100km** (danger and avoidable accident stages of STZ, only danger STZ and only avoidable accidents STZ)
- Independent variables = **Phase** (Phase 1 as reference) and **Country** (BE as reference)

Result (Contd.)

Table 4 GLMM estimation results

Fixed Effects*	Combined (danger + Avoidable accidents) STZs		Avoidable accidents STZ		Danger STZ	
	Estimate	p-value	Estimate	p-value	Estimate	p-value
Intercept	5.114	<0.001	3.652	<0.001	4.835	<0.001
Phase 2	-0.026	0.277	-0.055	0.064	-0.019	0.433
Phase 3	-0.071	0.003	-0.140	<0.001	-0.045	0.072
Phase 4	-0.116	<0.001	-0.195	<0.001	-0.088	<0.001
GER	-0.316	0.020	0.058	0.725	-0.457	0.001
UK	0.234	0.039	0.140	0.308	0.264	0.002
Random Effects						
User ID (Variance)	0.281		0.445		0.294	

* Phase 1 as reference for phases and 'BE' as reference for countries

- The **events per 100km decreased consistently** from Phase 1 (baseline) to each of Phase 2, Phase 3 and Phase 4 for the combined case
- **Country comparison** indicates **more events** in the **UK** compared to Belgium for all cases
- **Variance** between drivers was found **more** for **avoidable accident stage** than the **danger stage**

Differences between drivers

- Type A: Outcome is improved
- Type B: Outcome is not improved

Table 5 Drivers type and summary statistics

Country	Type A (outcome improved)		Type B (outcome not improved)	
	No. of Drivers	Percentage Decrease	No. of Drivers	Percentage Increase
BE	31 (65%)	-17.0%	17 (35%)	26.1%
UK	37 (76%)	-23.5%	12 (24%)	10.8%
GER	16 (64%)	-26.4%	9 (36%)	22.2%

- **Belgium and Germany:** (around) **Two thirds** showed improved outcomes
- **UK: Three quarters** showed improved outcomes

Discussion & Conclusion

Research Question 1

- For combined sample, statistically **significant decrease** in events from Phase 1 to Phase 4→ shows **effectiveness of the i-DREAMS interventions**
- The effectiveness holds for 'medium severity', 'high severity', 'total', 'vehicle control', 'speeding' and 'road sharing' events.
- Most significant results from Phase 3 to Phase 4 (when gamification elements were introduced)
- Greatest and most consistent impact on 'road sharing' events (data only available for Belgium and the UK).
- 'Vehicle control' events were least significantly impacted (no real-time warnings)

Research Question 2

- The **UK drivers** had the **largest number** of events and **greatest impact** on more 'risky' drivers compared to the other countries
- Little or inconsistent demographic differences across countries

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