INHIBITORY CONTROL AND PEER PASSENGERS PREDICT RISKY DRIVING IN YOUNG NOVICE DRIVERS – A SIMULATOR STUDY

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BACKGROUND

- Driving with peer passengers increases young novice drivers' crash risk (Williams et al., 2007).
- Two potential explanatory factors from developmental cognitive neuroscience (Yurgelun-Todd, 2007): **suboptimal cognitive control** and **increased reward sensitivity**.

COGNITIVE CONTROL

Cognitive control/executive functions:

- Collection of cognitive functions including inhibitory control, working memory, mental flexibility and planning.
- Important for the regulation of complex behavior, including performance of appropriate and inhibition of inappropriate actions.
- Adolescence: suboptimal cognitive control; it still advances until the age of about 30 (Crone & Dahl, 2012).
- **Present study: inhibitory control.**

REWARD SENSITIVITY

- Sensitivity of the affective brain system involved in the evaluation of rewards.
- Adolescence: **increased reward sensitivity at the start of adolescence**. Important source of rewards during adolescence: **peers**, their opinions and social evaluations.
- **Especially in rewarding contexts adolescents may be prone to risk taking behavior, when their increased reward-seeking impulses are not appropriately inhibited by cognitive control** (Figner et al., 2009).

PREVIOUS RESEARCH

- 2 previous studies: relation of cognitive control and reward sensitivity to the effect of peer passengers on risky driving for adolescent versus adult drivers in a driving video game (Gardner & Steinberg, 2005; Chein et al., 2010).
- Stronger increase in red light running in the presence of peers occurred in adolescents than adults.
- Lower cognitive control in adolescents independent of peer presence, greater reward-related brain activity in adolescents when peers were present.
- **Methodological aspects to be improved: video game played from a third-person, non-participating, side-view perspective, risky driving measurement limited to red light running, no discrimination of different functions of cognitive control (e.g., inhibitory control)**

AIMS

To investigate developmental differences in the effect of peer passengers on driving:

(1) 2 age groups given the hypotheses of lower cognitive control and reward sensitivity.

(2) 4 measures of risky driving (i.e., SDLP, road hazards, speeding, red light running),

(3) in a medium fidelity driving simulator,

(4) 1 function of cognitive control (i.e., inhibitory control) to investigate possible moderating effects of cognitive control.

METHOD

SIMULATED DRIVING TASK

STISIM 400 fixed-based driving simulator, large 180˚ field of view seamless curved screen.

2 Experimental sessions (after practice): 28 km, daylight driving, two-lane road, bidirectional traffic, including both inner- (50km/h) and outer-city sections (90 km/h).

–12 road hazards (e.g., a pedestrian crossing the road, a car suddenly appearing from behind a building and pulling back at the street)

–18 intersections equipped with traffic lights (10 red ; 4 green ; 4 yellow in randomized order).

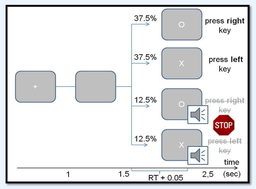
Experimental session 1: participants were instructed to drive as they would normally do.

Experimental session 2: participants drove together with a peer that they had been asked to invite and bring to the experiment. The peer sat in a chair, to the right of the driver's seat. The instruction to the drivers was to drive as they would normally do. Furthermore driver and peer were asked during the drive to behave and interact as they would normally do.

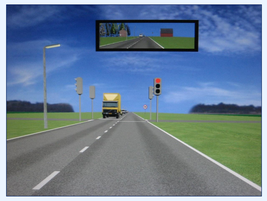
Risky driving behavior: standard deviation of lateral lane position (SDLP), responses to critical events (number of collisions), speeding (% total distance), and red light running.

EXAMPLE screenshot scenario

Stop Signal Reaction Time Task



EXAMPLE screenshot scenario red light



PARTICIPANTS: 2 age groups, matched in terms of gender ratios:

1.Age between 17-18 years (n = 30, mean age 17.8 years, 18 men) or 21-24 years (n = 20, mean age 21.5 years, 13 men)

2.A (full or provisional) driving license

3.No more than two years driving experience at the time of testing: there was a difference in self-reported driving experience of the 17-18 year-olds (1627 km/year) and the 22-24 year-olds (2883 km/year); $F(1,48) = 4.2$, $p = .047$). To control for this difference, driving experience was included in the analyses as a covariate.

COGNITIVE CONTROL: inhibitory control with the **Stop Signal Reaction Time (SSRT) task** (Logan & Cowan, 1984). Experimental session (after practice): 96 trials; interval between the stimulus and the auditory stop-signal was initially set 50 ms below participants' individual reaction time (RT). Subsequently the interval varied dynamically according to a staircase tracking algorithm, to converge on a stop-signal delay (SSD) at which the probability of stopping is 50%.

RESULTS

COGNITIVE CONTROL SSRT was comparable for the 17-18 year-olds (m=211ms; sd=44) and the 21-24 year-olds (m=209ms; sd=31ms), ($F(1, 48) < 1$, $p=.92$), indicating that basic cognitive control (i.e. inhibitory control) was similar across young drivers.

RISKY DRIVING BEHAVIOR

Four separate repeated measures ANOVAs for the different measures of risky driving behavior with **within-subjects factor peers** (2: no, yes), **between-subjects factors age** (2: 17-18 year-olds, 22-24 year-olds) **and driver gender** (2: male, female), and **continuous predictor variables inhibitory control** (i.e., SSRT) **and driving experience.**

Response to road hazards. Significant main effect of peers: the number of collisions with road hazards was lower in the ride with versus without peers.
SDLP. Significant main effect of peers: SDLP was lower in the ride with versus without peers.
Red light running. Significant main effect of peers: red light running was higher in the ride with versus without peers.

Speeding. Significant main effects age and gender: percentage speeding higher in 17-18 year-olds (20.3%) than 21-24 year-olds (12.0%), and in male drivers (19.9%) than female drivers (12.4%). Significant interaction effect of peers and inhibitory control: speeding increased in the ride with (versus without) peers only in the low inhibitory control group (12.4% versus 16.8%; $F(1, 20) = 17.0$, $p=.001$), whereas the difference in speeding between rides was not significant in the high inhibitory control group (19.3% versus 16.3%; $F(1, 20) = 1.7$, $p=.20$).

	No peers		Peers			Effects					
	17-18 yr	21-24 yr	17-18 yr	21-24 yr	inhibitory control	peers	age	gender	inh. X peers	age X peers	gender X peers
SDLP (meters)	m=.256 SE=.010	m=.257 SE=.012	m=.240 SE=.012	m=.237 SE=.015	F<1 p=.95	F=6.4 p=.01	F<1 p=.96	F<1 p=.34	F<1 p=.34	F<1 p=.76	F=2.5 p=.12
Speeding (% of distance)	m=18.7 SE=2.40	m=12.7 SE=3.0	m=21.8 SE=2.41	m=11.4 SE=3.0	F<1 p=.49	F<1 p=.49	F=5.0 p=.03	F=4.5 p=.04	F=4.2 p=.046	F=2.4 p=.13	F<1 p=.90
Red light running (# of times)	m=.07 SE=.04	m=.01 SE=.05	m=.16 SE=.08	m=.22 SE=.11	F<1 p=.34	F=4.4 p=.04	F<1 p=.99	F<1 p=.78	F<1 p=.39	F<1 p=.44	F<1 p=.88
Road hazards (# of collisions)	m=3.2 SE=.32	m=2.2 SE=.39	m=1.9 SE=.30	m=1.4 SE=.37	F<1 p=.74	F=14.4 P<.0005	F=3.0 p=.09	F<1 p=.72	F<1 p=.996	F<1 p=.38	F<2.6 p=.11

DISCUSSION

PEERS PREDICT RISKY DRIVING. The influence of peers can either be negative ('risk increasing') or positive ('protective'), depending on the specific driving measure.

(1) RISK INCREASING PEER EFFECTS: RED LIGHT RUNNING & SPEEDING.

- Prevailing explanations:
  - **heightened reward sensitivity** (Chein et al., 2010) - young drivers are more sensitive to the pressure from risk-loving friends (Monahan et al., 2009). In a previous study a comparable increase of speeding and red light running was found with a monetary reward (Jongen et al., 2011);
  - **Suboptimal cognitive control** (see below).
- **Typical driving violations:** large motivational component, conscious deviations from rules and safe practices (Reason, 1990); supported by the decrease in violations in the ride without peers: **young novice drivers are able to drive in a safer manner, but when peers are present they fail to do so.**

(2)PROTECTIVE PEER EFFECTS: SDLP & COLLISIONS ROAD HAZARDS.

- SDLP: possibly due to **increased cognitive workload** resulting from driver-passenger conversation (Heck & Carlos, 2008; Lee, 2007), as increased cognitive workload can lead to a decrease in lateral variation (Engström et al., 2005).
- Road hazards: possibly peers monitored the road and served as **additional 'risk detectors'** thereby improving the driver's ability to detect and respond to road hazards. Similar positive effects for passenger conversation when compared with a hands-free phone conversation: as passengers made references to traffic conditions, adjusted their conversation based on driving difficulty, and helped the driver navigate and identify hazards on the roadway (Strayer & Drews, 2007).

INHIBITORY CONTROL MODERATES PEER EFFECTS ON SPEEDING.

- In a sub-group with low inhibitory control an increase in speeding occurred with versus without peer passengers, while in a sub-group with high inhibitory control there was no effect of peer passengers on speeding. This suggests that **within a socio-emotional context, those adolescents with higher inhibitory control are more successful in resisting peer pressure effects.**
- **Cognitive control can be trained**, leading to improvements in driving performance (Cassavaugh & Kramer, 2009), but only speeding was affected: cognitive training as part of a broader program that teaches young drivers strategies of how to resist peer influences, and could be combined with an initiative such as GDL, requiring drivers to wait in driving together with peers (Fell, Todd & Voas, 2011).

LIMITATIONS.

- Sample composition: balanced sample in terms of gender of both driver and passenger would have been interesting, given differences in driving performance in function of gender differences that have been shown by others (McKenna et al., 1998; Ouimet et al., 2010; Simons-Morton, Lerner & Singer, 2005).
- No observation of the interaction of driver and passenger, e.g. to verify workload hypothesis SDLP.
- Not balancing order of trips across subjects: possible order effects

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