Fonds de recherche Société et culture Québec

Rapport de recherche

PROGRAMME ACTIONS CONCERTÉES

Les effets cumulatifs du manque de sommeil et d'un taux légal d'alcoolémie sur la conduite des jeunes conducteurs : l'influence de l'âge, du sexe et des facteurs cognitifs

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Partie A – Contexte de la recherche

Problématique Globally, road traffic crashes (RTCs) are the leading cause of mortality in young people irrespective of their level of driving exposure [1-4]. Quebec is not spared this loss of its young people. Young drivers aged 15-24 years represent 12% of licensed drivers yet account for 29% of fatalities related to RTCs [4, 5]. This selective risk, is attributed to human factors (e.g., reckless driving, speeding, drinking and driving) which together account for almost 90% of all fatal RTCs [6-11]. While introduction of measures such as restrictive graduated licensing programs have contributed to significant reductions in RTCs among young drivers including those in Québec, altering the behaviour in this group has been much harder to achieve through current policy strategies alone [12]. Lack of understanding of the complex pathways to heightened RTC risk in this vulnerable subgroup of drivers is a knowledge gap that hampers development of more effective targeted prevention and intervention strategies, and one that this proposal specifically targets.

Principales questions de recherche et / ou hypothèses Alcohol use and sleepiness are both endemic in the young driver population [13]. Young Quebecers typically consume alcohol during evening hours [14] when they are also more likely to be experiencing the effects of sleepiness. Perhaps not surprisingly, they are twice as likely to be involved in crashes between 9:00PM and 3:00AM compared to older drivers [15]. In adult drivers, low-level legal blood alcohol concentration (BAC) may not significantly impair driving performance in well-rested drivers, but when combined with sleep deprivation (SD), significant impairments result [16-18]. Strands of evidence suggest that young drivers, already a vulnerable group for RTCs, may have selective sensitivity to the impairing effects of both alcohol and SD. Yet we know little about whether younger drivers in fact are selectively vulnerable to the impact of alcohol and SD, Hence, this proposal's *principal research question* is:

What is the interplay between low legal BAC (BAC = 0.03, 0.05%) and SD of 6 hours on the driving performance in drivers?

The epidemiological data clearly indicate that RTC risk in general is moderated by both driver age and sex. Hence, a secondary question addressed in the research program is: What are potential moderating effects of age and sex that influence how alcohol and SD combine to selectively affect driving capacity and RTC risk in young drivers compared to older drivers? The influence on safe driving capacities of different combinations of SD and BAC are compared to the legal per se administrative benchmark for driving while impaired, namely BAC 0.05%.

Objectifs poursuivis The global health, social and economic costs related to traffic crashes remain so intolerably high that the United Nations General Assembly (A/64/L.44/Rev.1) has proclaimed 2011-2020 as the “Decade of Action for Road Safety” to spur international efforts. The unabated morbidity associated with young driver problem has spurred the Canadian Council of Motor Transport Administrators in 2011 to identify drivers 25 years or younger as a priority target for more intense preventative research efforts [19]. The increased recognition of both the significant role of alcohol and sleepiness in RTCs, as well as the significant gaps in our knowledge base, has led the Transport Research Board of the National Academies in 2011 to unambiguously encourage the RTC research community to “study the interaction of legal levels of alcohol use with fatigue.....to establish an evidence base to inform public education and policy and to begin to move towards community understanding and personal monitoring of fitness to drive” [20]. This proposal represents a Quebec response to these authoritative global calls for action and local knowledge needs regarding policy and intervention for the problems of drink-driving driving and fatigue; two of three leading cause of RTC-related mortality in Québec.

Partie B – Piste de solution en lien avec les résultats, retombées, et implications

Worrisome age-related crash fatality statistics ([e.g., 21, 22]) have led many jurisdictions to invoke *per se* laws setting a zero BAC threshold for novice drivers up to the age of 21 (implemented in Quebec as of April 15, 2012), after which restrictions are lifted. The introduction of this measure has been associated with important reductions in traffic fatalities [23]. Nevertheless, legislative strategies alone do not deter young drivers from engaging in drink driving and other risky driving behaviour [24]. In 2008 in Quebec, 44.4% of young drivers 16-19 years old killed in RTCs were under the influence of alcohol. It doesn't seem to take a lot of alcohol either. Alcohol involvement is involved in over half of fatally injured drivers aged ≤25 years each year, with approximately 40-50% of all RTCs involving young Canadians related to alcohol consumption at BAC levels well below the 0.08% legal threshold [25]. All told, while young age combined with alcohol is clearly a RTC risk factor, we cannot assert authoritatively the age after which young drivers can drink any amount of alcohol and drive safely – an issue of paramount importance for setting RTC prevention policies, and one of the principal research questions addressed in this proposal.

Our rationale for this study is that once we understand how low levels of alcohol and sleepiness interact in young drivers, it becomes more feasible to counter this interaction by developing, for example: 1) more evidence-informed restriction policies, such more precise age limits for zero BAC tolerance, or restricting night-time driving when SD is more likely; and 2) better individualized interventions, such as adjusting decision making and risk/hazard perception training in driver education based upon age and sex. Authoritative traffic safety bodies have expressly called for research to fill the knowledge gaps concerning the role of combined alcohol and SD on RTC risk and the underpinnings of the young driver's problem - intrinsically related issues targeted in the present proposal.

Effects of alcohol Overall, the present findings demonstrate that alcohol begins its negative influence on safe driving capacities at levels considered to be “legal” in fully licensed drivers. Alcohol intake to BAC ≈ .03% produced increased one cognitive factor associated with unsafe driving, specifically impulsivity. Impulsivity, involving thoughtless action that disregards potential negative future consequences, is associated with both engagement in impaired driving and reckless driving based upon our previous work [26] as well as others. In addition, BAC .05% produces negative effects on the capacity for adequate decision making. In our previous research, poor decision making capacity, where more immediate rewards are favoured over smaller rewards that are more advantageous over time, was a characteristic observed in both repeated impaired drivers [27] and reckless drivers [26]. (Our current thinking about the role of cognitive factors in risky driving, including impaired driving, especially in interaction with alcohol intake and sleep deprivation is provided in Appendix A). Consistent with these findings, we observed remarkable deterioration in safe driving capacities at BAC .05%, especially in vulnerable young male drivers.

Implications This result is consistent with other evidence that support reduction of the legal *per se* limits for impaired driving to improve public security and reduce the burden on health from road traffic injury [28]. As others have found, young male drivers are especially affected by elevated BAC, and this finding supports the role of even low legal doses of alcohol in their over-representation in road traffic crashes and fatalities. Committed re-appraisal of current *per se* BAC limits is necessary in general, while young male drivers appear deserving of added focus in prevention strategies.

Effects of sleep deprivation Sleep deprivation studied here involved an accumulated loss of sleep of 4.5 hours over a six-day period. We found evidence that this subtle level of sleep deprivation produced significant impairment in cognitive control capacities, particularly related to working memory, but to a lesser degree to decision-making capacity. Working memory has been related to reduced safe driving capacities in contexts where situational awareness and vigilance are paramount [29, 30]. In our previous work, decision making has been related to the propensity for both repeated impaired driving and reckless driving [26]. There was also evidence that the level of reduction in cognitive capacities by this level of sleep deprivation was equivalent to that seen after consumption of enough alcohol to achieve BAC .05%. Overall, these findings support the contention that sleep deprivation consisting of as little as a few hours in a week, a common pattern in young people, can negatively influence the cognitive capacities associated with safe driving to an extent that rivals that seen following excessive alcohol use. Greater awareness of the potentially significant effects of even modest levels of sleep deprivation on drivers' cognitive capacities is needed.

Sleep deprivation and alcohol The most direct findings related to driving safety provided by this research come from our assessment of simulation driving following exposure to sleep deprivation and alcohol intake. Our randomized placebo controlled study design with stratification by age and sex, and use of driving simulation that evokes driving behaviour in the safe controlled laboratory environment that reflects real word driving behaviour [26, 31], allow us to make causal inferences about the effects of exposure to sleep deprivation and alcohol intake on different at-risk subgroups.

First, our preliminary results validate the generalizability of the findings from our laboratory to the real world of driving. Increased risky driving was found in younger drivers vs. older drivers, and under BAC .05% compared to the placebo condition of no alcohol or sleep deprivation. These results were anticipated, as adolescents and young adults engage in more risk taking behaviour than older adults [32, 33], and alcohol intake plays an established role in increasing risk taking behaviour and injury risk [28].

More importantly, we found support for one of our main hypotheses. Specifically, driving performance of young males was more adversely affected by low dose of alcohol (BAC .03%) when combined with sleep deprivation compared to older males, or in females regardless of age. Indeed, the level of impairment by this combination of sleep deprivation and alcohol were comparable to that seen with a BAC level (i.e., BAC .05%), which is considered illegal in many western jurisdictions. This is a novel finding, and suggests an unfortunate confluence of modifiable yet subtle human factors (sleep deprivation, alcohol intake) that decrease safe driving capacities in young males.

Implications It has long been known that young drivers are at greater risk for road traffic crashes and fatalities at any BAC level compared to older drivers. This has been interpreted as resulting from young drivers' inexperience behind the wheel, with alcohol use, and their propensity for sensation seeking and risk taking, especially in young males [36]. To these risk factors for the "young driver problem", we can empirically support the addition of sleep deprivation as a further, potentially hidden risk factor. Increasing public and professional awareness of the added risk of sleep deprivation to their overall vulnerability to road traffic crashes and fatalities would be an important prevention strategy to pursue.

Young male drivers 18-22 in Quebec are issued a restricted license that sets a zero tolerance for alcohol. Nevertheless, it is clear that while most young drivers adhere to this rule, some do not. The reasons for non-compliance to this clear directive are likely complex. In the present study, we revealed the contribution of sleep deprivation not only in their ability to safely drive, but its negative impact on cognitive processes that could have other dangerous consequences. The trajectory to impaired driving does not begin at the time of alcohol intake in most cases, but with choices and actions taken before alcohol intake occurs. Working memory and safe decision-making capacities are relevant in this scenario, as they are related to awareness of the ability to learn and follow instructions and rules, adequate situational awareness of one's surroundings and the hazards that it presents (e.g., risk of alcohol misuse and crash risk), and the ability to seek advantageous but longer-term objectives (e.g., greater traffic safety) rather than being lured into seeking risky "quick fix" solutions (e.g., convenience, insisting on driving to a drinking venue). Along these lines, sleep deprivation is likely to play a role in how a young driver finds himself not only behind the wheel in a significantly impaired state, but also in non-compliance with zero tolerance laws.

Overall, the role of subtle levels of sleep deprivation in the trajectory to both risky driving and impaired driving was underscored in the present study. The findings here suggest that sleep deprivation needs to be better integrated into an overall prevention strategy to the "young driver problem". Both public health messages, and remedial approaches to risk assessment, especially targeted at young male drivers, would be well-advised to place more emphasis on chronic, limited levels of sleep deprivation in the complex trajectories leading to both risky and impaired driving.

PARTIE C - MÉTHODOLOGIE

Methodological overview of trial design The overarching goal of this proposal is to examine interactions between blood alcohol concentration levels (i.e., BAC: 0.0%,.03%, .05%); levels of sleep deprivation: rested (✖SD), 6 hours of sleep deprivation (✔SD) on driving performance of drivers aged 18-34 years. We use a between-subject, randomized controlled experiment, with stratification by age and sex, and random assignment to five conditions. Figure 1 in Appendix B provides an overview the study recruitment, assignment to conditions, stratification by sex and age, and sample size targets. Table 2 in Appendix B describes the experimental sessions, manipulations and tests. The entire protocol is conducted at the Douglas Hospital Research Centre in Montreal.

Briefly, study candidates are first telephone screened for eligibility and if so, scheduled to come to the lab for three sessions: 1) baseline assessment; 2) five days later, a session for randomization and SD instructions; and 3) seven days later, experimental session with alcohol dosing. Following the baseline assessment, stratification of Ss into 3 age [i=18-21; ii=22-24; iii=30-34] X 2 sex [A=male/B=female] levels is followed by randomization five days later into one of the five experimental conditions [i) 0.0%BAC, ✖SD; ii) .03%BAC, ✖SD; iii) 0.0%BAC, ✔SD; iv) .03%BAC + ✔SD; v) 0.05% BAC, ✖SD]. The final experimental session is scheduled for six days after randomization, and specifically tested participants' driving behaviour using driving simulation. All participants receive $100 compensation per visit.

Appendix C provides screenshots of the apparatus and tests to objectively measure sleep monitoring using Actiwatch® (Picture 1), the computerized version of the Iowa Gambling Task (IGT) (Picture 2), and the driving simulator set-up and scenarios for evaluating driving capacities (Picture 3). Analyses are primarily based upon planned comparisons between the four experimental groups and controls.

PARTIE D - RÉSULTATS

Recruitment This study was appended to a larger study funded by CIHR (review Figure 1, Appendix B), which allows us to maximize the scientific responses regarding questions pertinent to both CIHR and this Programme Actions concertées of les fonds de recherche du Québec - Société et culture. A description of the recruitment achievement since project initiation to the present time is provided in Appendix D Table 1. We have succeeded in recruiting 259 of the 300 participants targeted (86%). Our sample size target of N = 300 for the overall study was carefully calculated to adequately power analyses to test our hypotheses (i.e., at β=.20, α = .05). We are also precisely stratifying our recruitment by age and sex, an objective that is also incomplete for the moment. We

Given the scope of the study, the need to fill six specific stratification categories (i.e., age (3) X sex (2) = 6), and other under-estimated challenges of recruitment, our recruitment and data collection has taken longer than anticipated. We are in the very final stages of recruitment, and estimate that it will be terminated in December, 2017. Nevertheless, we present results using the available sample on: i) the integrity of our BAC and SD manipulations; ii) the impact of BAC and SD on cognitive indicators associated to risky driving; and iii) the impact of BAC and SD on driving capacities in simulation. For these analyses, we use a α for inferences of $p < .05$.

Integrity of alcohol manipulation A basic feature of our experimental study design was to manipulate the BAC of participants in the different alcohol groups. Specifically, we wanted to expose two groups to BAC of .03%, and the final group to .05%. With randomization, this would allow us to make causal inferences about the effect of alcohol and alcohol dose on cognitive and driving performance. Figure 1 provides unequivocal evidence of the success of this key manipulation during experimental session 3. Analyses indicated that while no significant differences were detected between the two groups with

.03%, the .05% group was different from the two .03% groups. Data from the two 0% BAC groups are not presented, as their BAC remained unchanged at 0%. These groups were provided a placebo 0.0% BAC beverage that tasted like alcohol but contained no alcohol content.

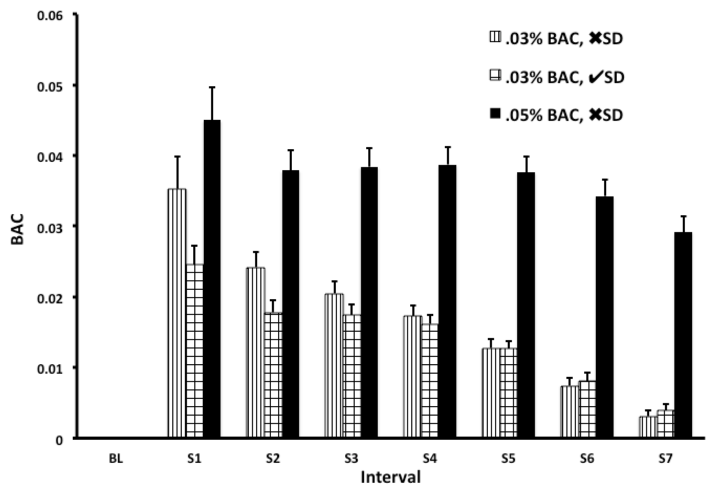

Figure 1. BAC values for the three positive BAC groups at baseline (BL) and across the seven first sampling sessions after alcohol administration (S1-S7) at 10 minute intervals.

Integrity of sleep manipulation

Another basic feature of the experimental study design was to manipulate sleep deprivation, specifically one group are exposed to a placebo condition (i.e., 30 minutes exposure to a sham "therapeutic" lamp for 20-30 minutes) that participants were told would produce the equivalent of sleep deprivation. The true sleep deprivation condition involved instructions to participants to wake up 60 minutes earlier than normal over 6 days between experimental sessions 2 and 3. With randomization, this would allow us to make causal inferences as to the effect of sleep deprivation on cognitive and driving capacities. Figure 2 shows an early analysis of mean sleep times of the group that was exposed to sleep deprivation versus all other groups given the placebo condition, as objectively measured using actigraphy. On average, the sleep deprivation manipulation resulted in approximately 4.5 hours less sleep after six days at Visit 3 compared to the other no sleep deprivation conditions.

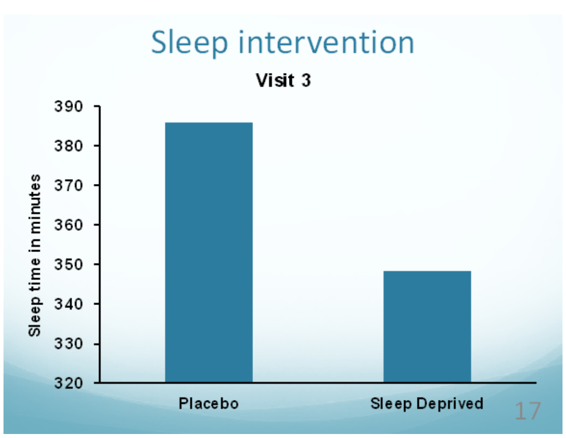

Figure 2. The results of six days of either the sleep deprivation condition or the placebo sleep deprivation conditions, in average hours of actual sleep time.

<u>Effects of alcohol and SD on executive control</u> The Iowa Gambling Task (IGT) measures decision making capacities. IGT scores can indicate risky or disadvantageous decision making. When individuals favour smaller short-term gains versus greater longer-term gains, the former is considered an indicator of proneness for disadvantageous decision making. In analyses of the IGT performances of our five groups (see Figure 3), we detected two trends for differences between our control group (0.0%BAC, ✖SD) and those participants who were either sleep deprived but not under alcohol (0.0%BAC, ✔SD), or under .05%BAC but no sleep deprivation (0.05% BAC, ✖SD). These differences indicate that these groups showed disadvantageous decision making “under ambiguity” (i.e., at the beginning of the task).

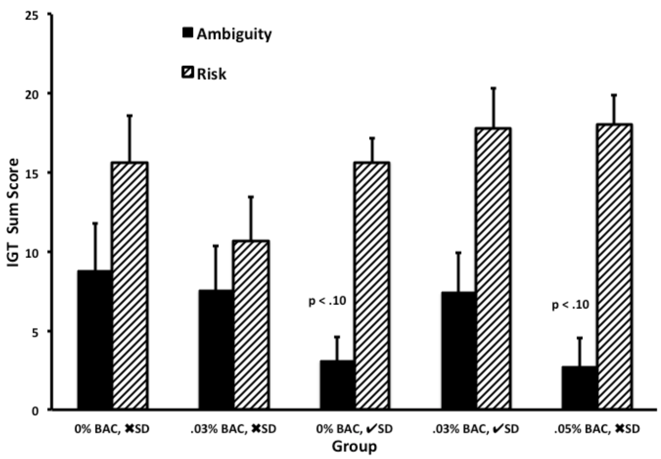

Figure 3. Scores on the Iowa Gambling Task (IGT) by group (BAC = blood alcohol concentration, SD = sleep deprivation), N = 214.

In our other work, deficits in this kind of decision making have been associated with drivers prone to speeding and other forms of non-alcohol related reckless driving behaviours [26], as well as driving while impaired [27]. Thus, these results suggest that the effect sleep deprivation on this cognitive indicator of risky driving is comparable to that seen when under the effects of .05% BAC. Interestingly, similar effects were not seen with lower levels of BAC alone (.03%), or even when a lower level of .03% BAC was combined with sleep deprivation. In the former observation, it is possible that .03% BAC is not sufficient alone to impair this cognitive process. The latter observation is more mysterious. One possibility is that a lower level of alcohol dampens the deleterious effect of sleep deprivation on decision making. Along these lines, the awareness of having consumed alcohol triggers in participants compensatory behaviour (e.g., increased vigilance and attention).

Working memory is one facet of the executive control system that is responsible for the transient holding, processing, and manipulation of information, which is important for reasoning, and adaptive decision making and behaviour. It has been related to reduced safe driving capacities when demands for situational awareness and vigilance are important [29, 30]. More in-depth investigation of the effects on neuropsychological function of sleep deprivation was carried out by a member of our team (Santisteban, JA et al., Experimental cumulative sleep restriction impairs working memory but not decision making). He found that poorer performance on a working memory task resulted from the sleep deprivation alone condition (0.0%BAC, ✔SD) compared to the control condition (0.0%BAC, ✖SD), ($F_{(1,49)}=5.18$, $p < 0.05$).

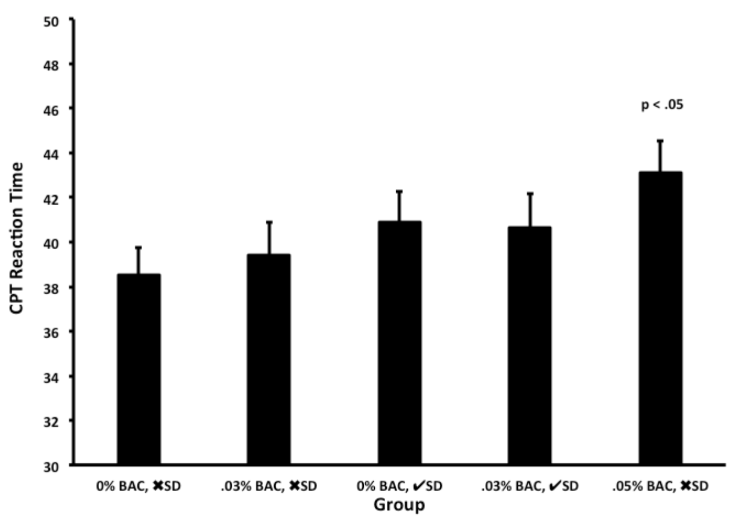

Figure 4. Hit Reaction Time scores on the Continuous Performance Task (CPT) by group (BAC = blood alcohol concentration, SD = sleep deprivation), N = 214.

Impulsivity is another important facet of the executive control system that is strongly associated with the tendency to engage in frequent risky driving [34]. When measured behaviourally using functional neuropsychological tasks like the Continuous Performance Task (CPT) (i.e., as opposed to paper-and-pencil questionnaires like the Barratt Impulsivity Scale), the ability to advantageously exercise control over one's actions to optimize outcomes is assessed. In our previous work, we have found it to be a characteristic of DWI recidivists [35-37].

Our analyses on CPT data here also yielded suggestive results in the context of the effect of acute alcohol intake as well. Figure 4 shows that .05% BAC increases reaction time compared to the control condition. Shorter reaction time is a behavioural measure of impulsivity, where more rapid responses suggest impulsive, thoughtless responding. As longer delays in reaction represents the antipode of impulsivity on this measure, this result suggests that under BAC .05%, participants performed less impulsively. Figure 5 depicts scores on the perseveration scale of the CPT, which measures erroneous random or anticipatory responses to stimuli. Thus, higher scores on perseveration indicate more impulsivity. Analyses indicated that .03% BAC resulted in higher scores on this scale. While seemingly contradictory, the former findings could be signifying a slowing in response rates with alcohol intake, which is not adaptive when fast reactions to emergency situations are needed. However, the latter responses, signaling higher perseveration scores, reflect less thoughtful or adaptive behaviour (i.e., more impulsive).

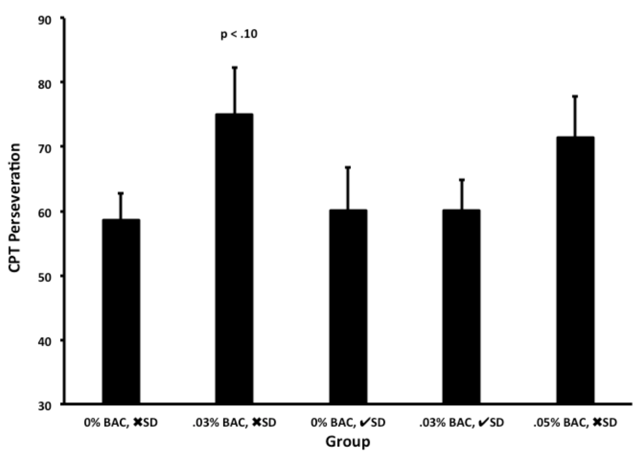

Figure 5. Perseveration scores on the Continuous Performance Task (CPT) by group (BAC = blood alcohol concentration, SD = sleep deprivation), N = 214.

<u>Effects of alcohol and SD on driving</u> Our main dependent variables for understanding the impact of sleep deprivation and alcohol intake on driving capabilities were derived from driving simulation. Here we present results from our analyses of two key dimensions related to safe driving: driving performance and risky driving. Lateral deviation (i.e., lane keeping) is a measure of driving performance that is sensitive to the effects of both alcohol and sleep deprivation in adult drivers [38]. It measures the ability of the driver to maintain his/her position in a

lane. It is operationalized as the standard deviation of lateral movement measured across specific scenarios in a simulation drive. As such, it is a measure of driving control, with greater standard deviation indicating less control. Mean speed is an established indicator of driving risk taking. Higher speeds is associated with increased crash risk; in this simulation drive, mean speed has been found to discriminate between safe and risky drivers in our previous research [26]. The results of our BAC and SD manipulations on driving behaviour is depicted in Figures 6 and 7, with stratification by age and sex.

Driving performance

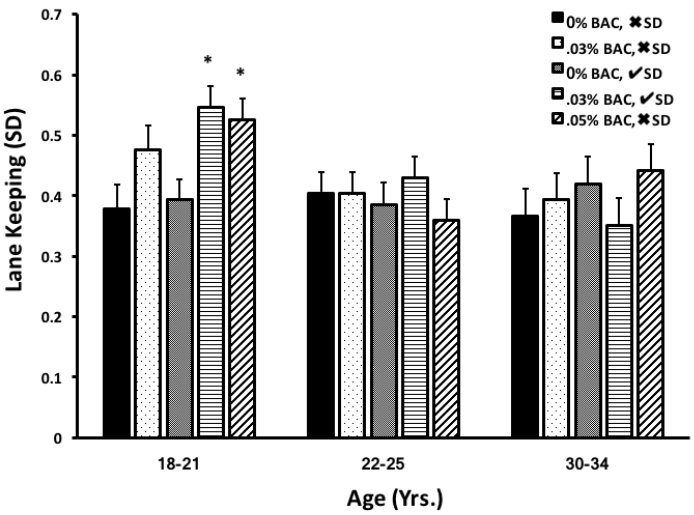

Figure 6. Effect of sleep deprivation and BAC on lane keeping in male drivers (n = 122).
* p < .05

Figure 6 at right shows that, when compared to drivers who were exposed to the placebo condition (i.e., 0% BAC,✖SD), young male drivers exposed to both the .03% BAC,✔SD and .05% BAC,✖SD conditions showed significantly poorer driving performance. Importantly, we could detect no difference between the young males drivers in the .03% BAC,✔SD and .05% BAC,✖SD conditions. This would suggest the possibility that poorer performance caused by exposure to the .03% BAC,✔SD was of a similar magnitude to that caused by alcohol at a level equivalent to.05% BAC.

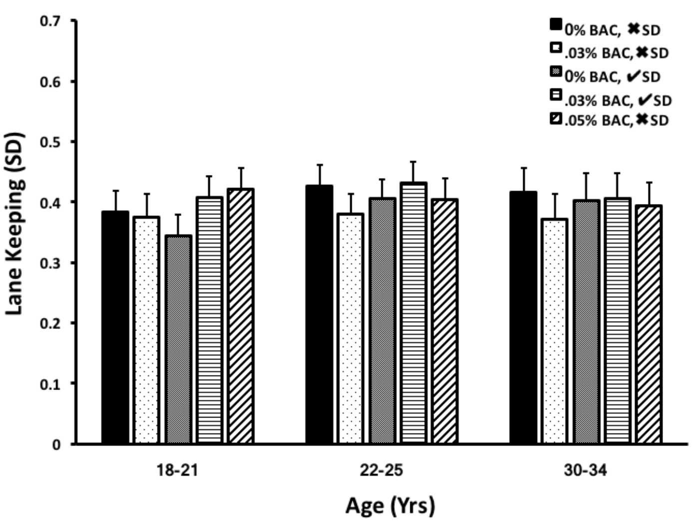

Figure 7 shows the impact of BAC and SD on lane keeping in females. No age-based

Figure 7. Effect of sleep deprivation and BAC on lane keeping in female

differences between the placebo condition (i.e., 0% BAC,✖SD) and the other conditions were detected.

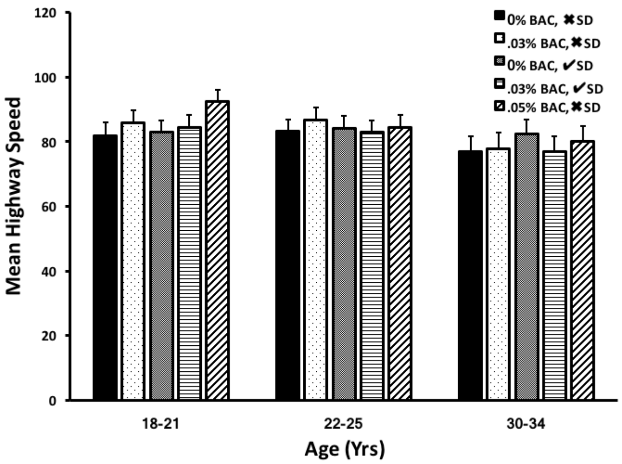

Figure 8. Effect of sleep deprivation and BAC on mean highway speed in male drivers (n = 122). * p < .05

Risky driving

Figures 8 and 9 depicts the impact of BAC and SD on risky driving in males and females, respectively. A significant main effect of age was detected [$F(2,224) = 3.3$, $p = .04$, $\eta^2 = .03$, with the 18-21 group driving faster on average than the 30-34 group, irrespective of sex. As well, a trend for a main effect of condition was detected ($p = .09$), with the .05%, BAC,✖SD condition resulting in faster driving than the placebo condition. No age-based differences were detected between the placebo condition (i. e., 0% BAC,✖SD) and the other conditions in either males or females.

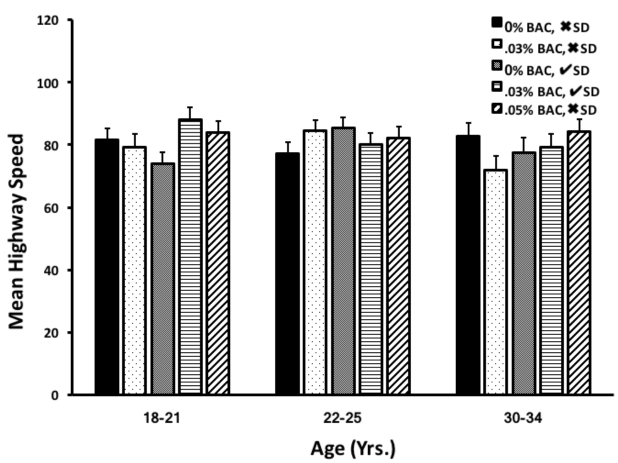

Figure 9. Effect of sleep deprivation and BAC on mean highway speed in female drivers (n = 134). * p < .05

PARTIE E - PISTES DE RECHERCHE

Overall, the apparent additive effects of modest levels of sleep deprivation and alcohol consumption, a combination that is common in young people, deserves far more research attention. In addition, the deep cognitive level of analyses used here provides some direction for future research into causal mechanisms underpinning driving risk, and the interventions that could intercept them. Three cognitive dimensions linked to safe driving, impulsivity, decision making and working memory, seem particularly vulnerable to sleep deprivation.

Hence, future research is needed to: i) replicate the present findings; ii) disentangle the relationships between cognitive factors and driving capacities and risk taking under both alcohol and sleep deprivation; iii) disentangle the effects of sleep deprivation on the cognitive factors that can promote risk taking and impaired driving; and iv) design and evaluate interventions aimed at increasing young drivers' ability to make safe driving choices when fatigued.

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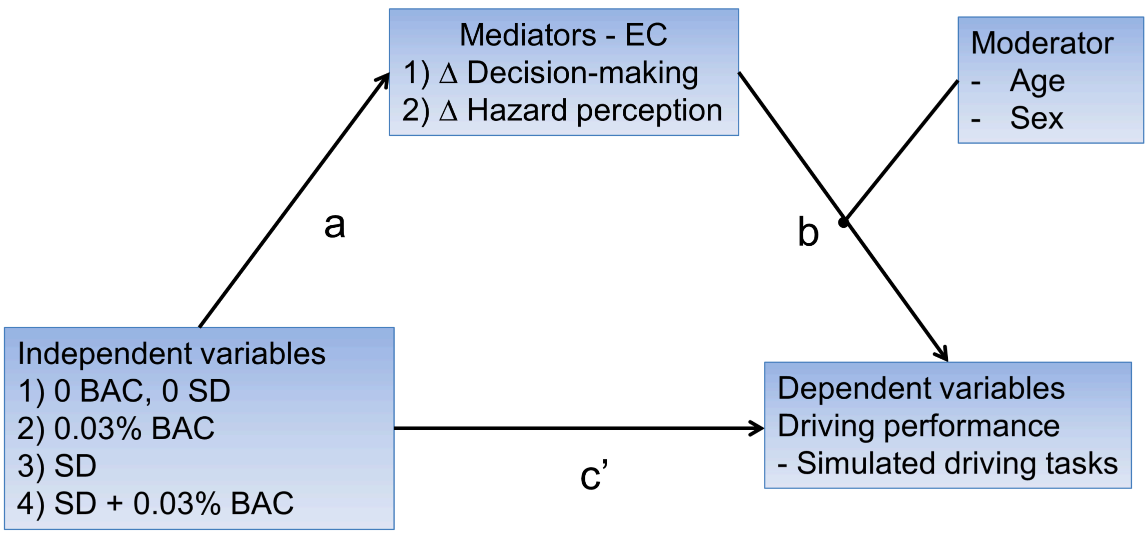
Appendix A

Figure 1 Proposed mediation-moderation model



Exploratory analyses of expected influences of Sleep Deprivation (SD) and 0.03% Blood Alcohol Concentration (BAC) on driving performance expected to be moderated by age and gender and mediated by Executive Control (EC)

Appendix B

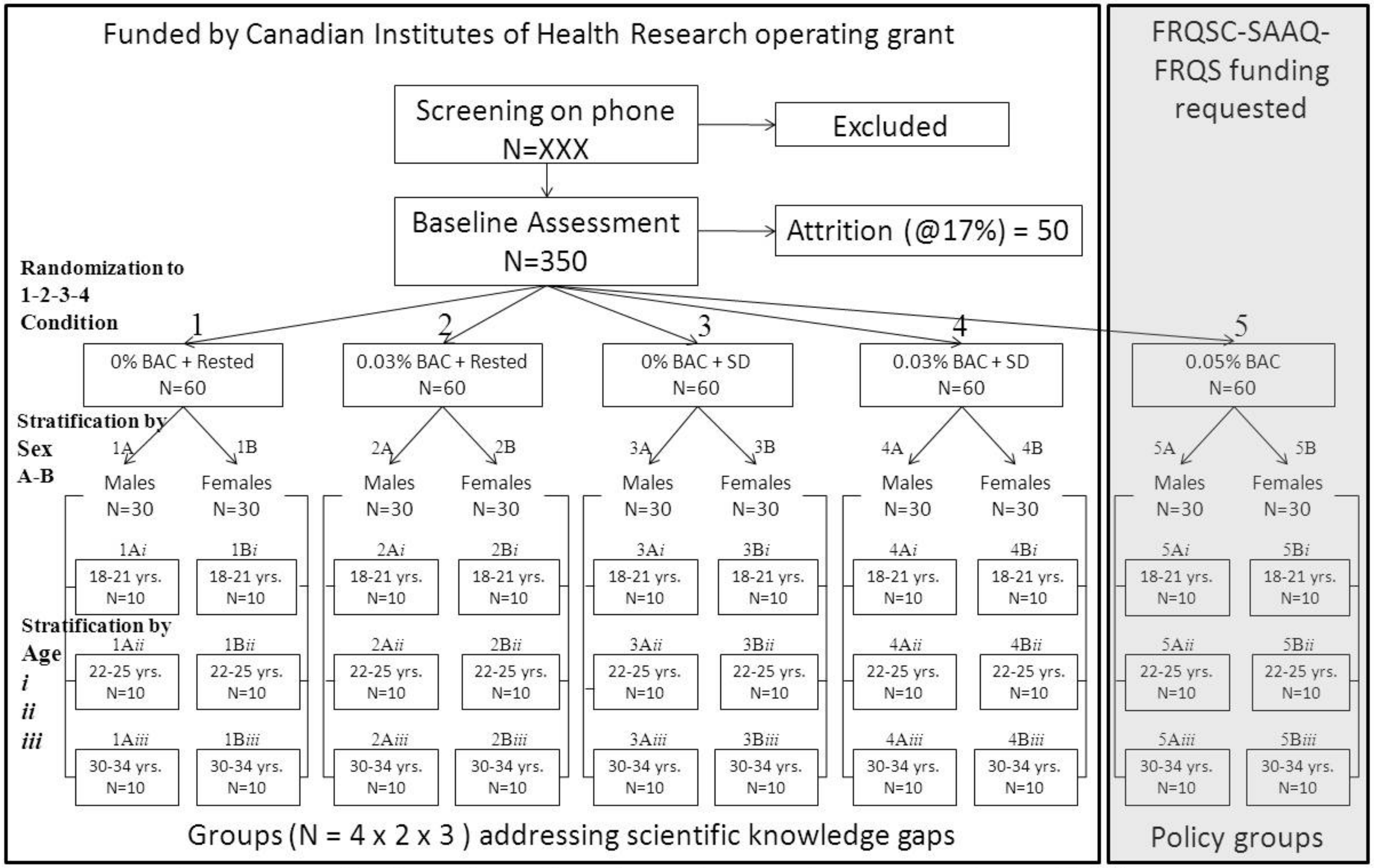


Figure 1. Study Flow Through and Random Assignment and Stratification

Table 2. Description of initial, baseline and experimental sessions

Session	Phone screening		Baseline recruitment, assessment		Actiwatch® data collection		Experimental session
			Day 0		Day 6		≈Day 13
Duration							
- 10-15mins	Demographics, PSQI, AUDIT, DUDIT, BDI, health screening						
Time							
- 1100-1129hrs			Arrival, Consent forms, Snacks*			**S**	Arrival, Snacks*
						D	
- 1130-1150hrs			Confirm –ve BAC, Drugs, Pregnancy & detailed health screening				Confirm –ve BAC, SD, Drugs, Pregnancy
				5	A	**I**	
- 1151-1200hrs			Simulation practice	**Day**	N	**N**	Simulation practice
					Y	**D**	
- 1200-1215hrs			Driving questionnaires	**N**		**U**	**Alcohol dosing, monitoring begins**
				O	T	**C**	
- 1216-1255hrs			UPPS – I	**R**	I	**T**	≈Achieve 0.03% BAC
				M	M	**I**	
- 1256-1314hrs			Break, Light snacks*	**A**	E	**O**	Break, Light snacks*
				L		**N**	
- 1315-1345hrs			IGT		60 min approx.		IGT
						F	
- 1346-1415hrs			CPT			**O**	CPT
				S		**R**	
- 1416-1445hrs			Simulation task 1	**L**			Simulation task 1
				E		**7**	
- 1446-1514hrs			Simulation task 2	**E**			Simulation task 2
				P		**D**	
- 1515hrs			Briefing & Actiwatch instructions			**A**	Debriefing (performance perception)
				D		**Y**	
- 1530hrs			Session end	**A**		**S**	Waiting period (until BAC=0)
				T			
- 1601hrs				**A**			Session end

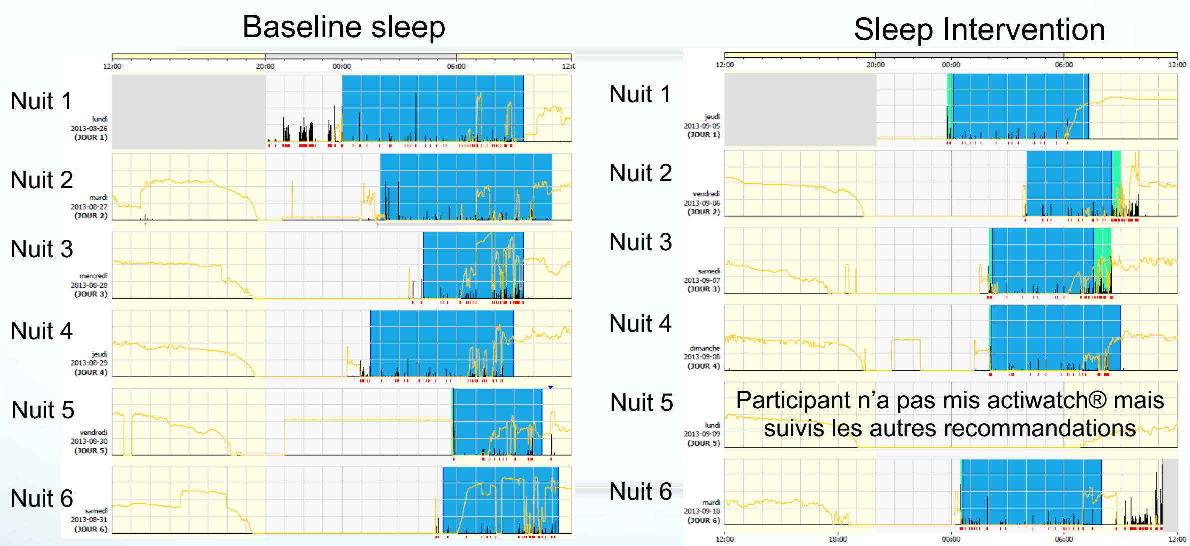
AUDIT Alcohol Use Disorders Identification Test
BAC Blood Alcohol Concentration
BDI Beck Depression Inventory II
DUDIT Drug Use Disorders Identification Test
IGT Iowa Gambling Task
CPT Continuous Performance Test
PSQI Pittsburgh Sleep Quality Index
SD Sleep deprivation

UPPS-1 Urgency, Premeditation (lack of), Perseverance (lack of), and Sensation seeking (UPPS) Impulsive Behavior Scale 1
* E.g. cheese rolls

Appendix C

Picture 1. Actiwatch® AW64 series

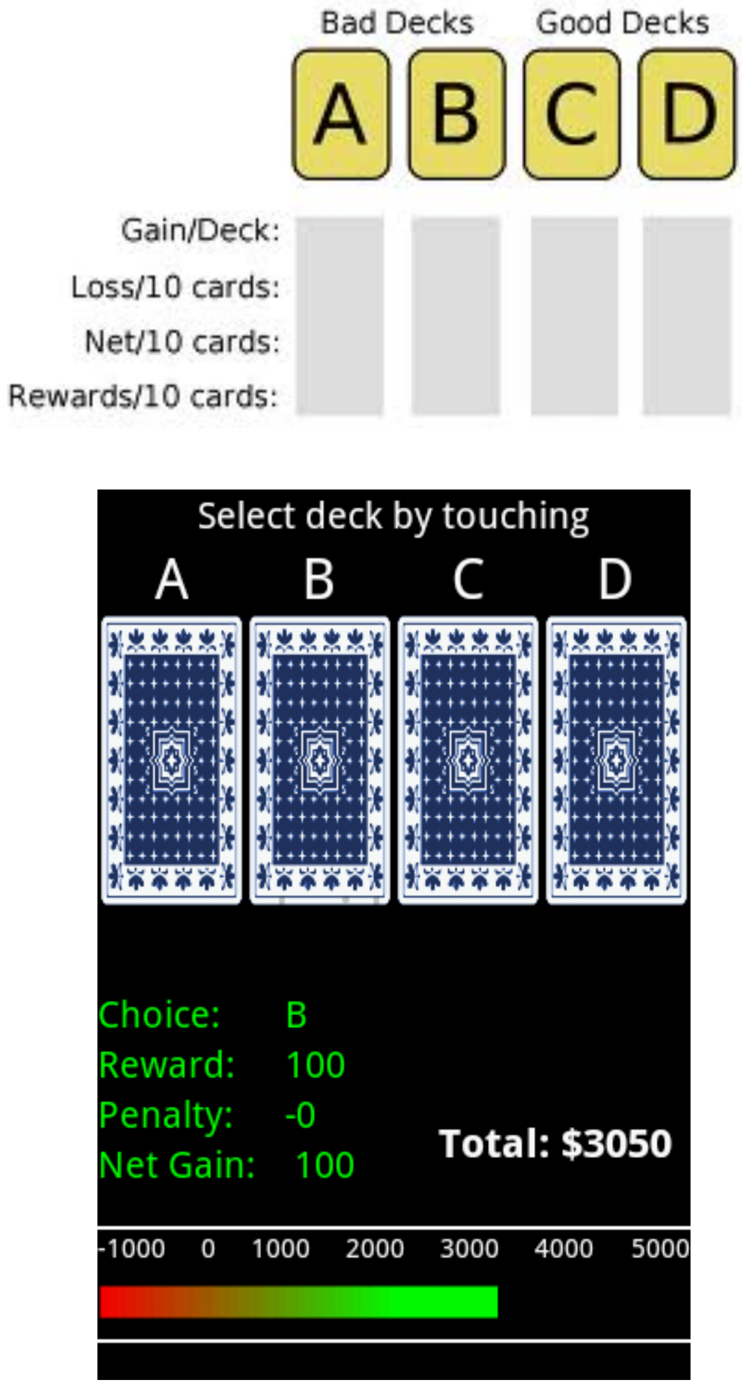
Exemple de données actiwatch® : pilote n°3



Nuit	Heure de début	Heure de fin	Durée (en minutes)
1	00:02:00	09:29:00	567
2	02:00:00	10:59:00	539
3	04:15:00	09:29:00	314
4	01:31:00	08:59:00	448
5	05:52:00	10:29:00	277
6	05:20:00	11:19:00	359
Moyenne	03:10:00	10:07:20	417 (≈ 6,9h)

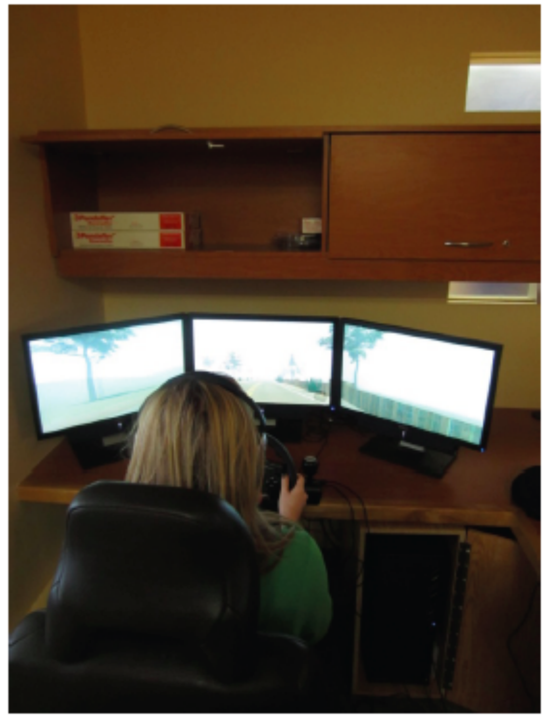
Nuit	Heure de début	Heure de fin	Durée
1	00:08:00	07:19:00	431
2	04:00:00	08:31:00	271
3	02:13:00	07:34:00	321
4	02:10:00	08:59:00	409
5	Participant n'a pas mis l'actiwatch®		
6	00:38:00	07:59:00	441
Moyenne	01:49:48	08:04:24	374,6 (≈6,2h)

Picture 2. Screen shot of Iowa Gambling Task - Neuropsychological measure of risk taking



Picture 3. Driving simulation

Simulator with steering wheel & brakes



Participant on simulator

Hazard perception: Children crossing from non-designated place

Driving risk taking: To pass or not?

Appendix D

Table 1. Number of calls, inclusion and exclusion, and recruitment total as of November 2017.