

The Role of Behavioral Phenotypes on Impaired Driving Recidivism Risk and Treatment Response to Brief Intervention: A Preliminary Study

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Background: Heterogeneity in the driving while impaired (DWI) offender population and modest outcomes from remedial programs are fueling interest in clarifying clinically significant DWI subtypes to better assess recidivism risk and target interventions. Our previous research identified 2 putative behavior phenotypes of DWI offenders with distinct behavioral, personality, cognitive, and neurobiological profiles: (i) offenders primarily engaging in DWI (pDWI); and (ii) offenders engaging in DWI and other traffic violations (MIXED). Here, we evaluate these phenotypes' clinical significance for prediction of recidivism and intervention targeting.

Methods: DWI recidivists participating in a previous randomized controlled trial ($N = 184$ comparing brief motivational interviewing (BMI) and an information and advice control condition (IA) were retrospectively classified as either pDWI ($n = 97$) or MIXED ($n = 87$). Secondary analyses then evaluated the effect of this phenotypic classification on self-reported 6- and 12-month alcohol misuse outcomes and documented 5-year DWI recidivism violations, and in response to either BMI or IA (i.e., pDWI-BMI, $n = 46$; MIXED-BMI, $n = 45$; pDWI-IA, $n = 51$; MIXED-IA, $n = 42$). Two hypotheses were tested: (i) MIXED classification is associated with poorer alcohol misuse outcomes and recidivism outcomes than pDWI classification; and (ii) pDWI paired with BMI is associated with better outcomes compared to MIXED paired with BMI.

Results: MIXED classification was associated with significantly greater risk of recidivism over the 5-year follow-up compared to pDWI classification. Moreover, the pDWI-BMI pairing was associated with significantly decreased recidivism risk compared to the MIXED-BMI pairing. Analyses of 6- and 12-month alcohol use outcomes produced null findings.

Conclusions: The clinical significance of phenotypic classification for risk assessment and targeting intervention was partially supported with respect to recidivism risk. Prospective investigation of this and other behavioral phenotypes is indicated.

Key Words: Driving While Impaired, Alcohol, Typology, Phenotype, Treatment Responsivity, Brief Intervention, Motivational Interviewing.

DESPITE CONCERTED PREVENTION efforts, alcohol continues to pose a significant burden on global health and mental health (Whiteford et al., 2013). Road traffic crashes, a source of morbidity (World Health Organization [WHO], 2015), represent a major consequence of alcohol misuse. In Canada, an estimated 30% of fatal traffic crashes involve driving while impaired with alcohol (DWI)

(Perreault, 2016). While risk of fatal crashes not related to alcohol has fallen significantly over the past decades, no parallel reduction has been observed for alcohol-related crashes (Romano et al., 2018). Repeat DWI offenders (i.e., recidivists) pose a particular risk to public safety compared to drivers with no DWI history. They are at greater risk for substance misuse problems, premature all-cause mortality (Impinen et al., 2010), future DWI violations (Rauch et al., 2010), and fatal crashes (Fell, 2014). Moreover, when compared to other drinking drivers, they are overrepresented in fatal collisions involving blood alcohol concentration (BAC) of 0.08% or greater by a factor of 3.8 (Fell, 2014). Thus, intervening with offenders to curtail recidivism represents important public health and traffic safety strategies.

In many jurisdictions, evaluation and mandated assignment to psychosocial intervention following a DWI offense are administrative prerequisites for relicensing. Their specific content and orchestration vary, but the scientific literature indicates their modest effectiveness for accurately assessing risk and preventing recidivism (Anderson et al., 2000; Miller

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et al., 2015). The marked heterogeneity in the alcohol use patterns and other individual characteristics of DWI offenders (Nochajski and Stasiewicz, 2006), and the growing awareness that alcohol misuse is a necessary yet insufficient explanation or predictor of persistent DWI behavior (Dugosh et al., 2013), further complicate prevention efforts. This has led to the conclusion that a focus on alcohol use disorder in DWI risk assessment and a “one-size-fits-all” approach to recidivism prevention are unlikely to provide equivalent benefits for all offenders (DeMichele et al., 2016).

Accordingly, a persistent hypothesis in the DWI recidivism prevention field posits that targeting intervention protocols to offender characteristics can improve outcomes. One approach to testing this hypothesis involves identification of homogeneous offender typologies whose members would likely respond better to interventions that address their specific risks and needs. To derive these typologies, studies have relied predominantly on cross-sectional designs, psychometric measurement, and statistical methods like cluster analysis (Ball et al., 2000; Okamura et al., 2014). However, this empirical approach has resulted in inconsistent typological formulations between studies, including their number and constituent dimensions (e.g., Fernandes et al., 2007, 2010), and limited insight into the mechanisms underlying their maladaptive behavior. Few studies have sought to clarify the prognostic significance of these typologies through longitudinal research, or the distinct cognitive and neurobiological mechanisms contributing to their DWI behavior. A potentially more clinically meaningful approach involves identification of behavioral phenotypes, whose members exhibit common: (i) maladaptive behavioral manifestations; (ii) prognostic severity; (iii) personality, cognitive, and neurobiological features that plausibly explains maladaptive behavior; and (iv) selective responsivity to specific interventions (Waite et al., 2014).

Along these lines, foundational research by our research group (Brown et al., 2016) examined 2 candidate behavioral phenotypes prevalent in the DWI population. One was characterized by primary engagement in DWI behavior with little evidence for other moving traffic violations. The second was characterized by a generalized traffic risk-taking pattern including violations for DWI as well as for dangerous driving not related to alcohol misuse (e.g., speeding, hit-and-run). Multidimensional comparison between these phenotypes and non-DWI controls confirmed that each phenotype possessed markedly distinct features. Primarily engaging in DWI (pDWI) offenders showed greater alcohol misuse and cognitive control weakness that was not accompanied by risk-taking propensity when sober, suggesting a pathway to DWI involving heightened sensitivity to alcohol’s deleterious effect on cognitive and behavioral control systems (Fillmore, 2012). In contrast, the offenders engaging in DWI and other traffic violations (MIXED) exhibited broad behavioral, personality, cognitive, and neurobiological anomalies that suggested the diminished neural affective regulation and behavioral control seen in “fearlessness” (Carroll et al.,

2017). These differences are likely to predict not only varying levels of prognostic severity, but selective responsivity to distinct interventions as well. The present study addresses the clinical meaningfulness of these putative behavioral phenotypes by testing their prognostic significance, in this case recidivism risk, and their association to selective responsivity to 2 different types of brief intervention.

In a separate line of inquiry, our research group compared the efficacy of a brief intervention (i.e., one 30-minute session), brief motivational interviewing (BMI) versus an information and advice control intervention (IA) of the same duration (Brown et al., 2010; Ouimet et al., 2013). DWI offenders frequently exhibit poor problem recognition and ambivalence about engaging in remedial relicensing programs and altering problem drinking (Brown et al., 2008; Voas et al., 2010). As BMI attempts to rapidly (i.e., in 1 to 4 sessions) evoke reappraisal of risky behavior, resolution of ambivalence, and intentions to change behavior (Miller and Rollnick, 2002), it seems well suited to meet these therapeutic challenges. The results indicated superior outcomes for drivers who received BMI. This is in line with other reports (e.g., Smedslund et al., 2011; Utter et al., 2014) that, compared to a control condition, supported BMI’s greater benefit for curtailing short-term alcohol misuse, and to a lesser extent DWI recidivism over longer follow-up periods. The size of BMI’s effect observed in previous studies has been modest, however. Studies have shown that participants exhibiting more severe alcohol misuse (for a review, see Ouimet et al., 2014) and lower sensation seeking personality features (Feldstein Ewing et al., 2009) benefited the most from exposure to BMI. As these features are consistent with those characterizing pDWI offenders, it is plausible that the pDWI offenders would show selective responsivity to BMI compared to MIXED offenders.

To further this line of research, the present study focuses on the clinical meaningfulness of pDWI and MIXED phenotypes by addressing the following overarching question: What can these phenotypes tell us about offenders’ long-term prognosis and responsivity to different interventions? By using data from a previous randomized controlled trial of BMI with DWI offenders (Brown et al., 2010; Ouimet et al., 2013), and phenotypic classification criteria derived from a separate study in a distinct risky traffic offender sample (Brown et al., 2016), a platform was built to practicably address these questions via secondary analyses. Participants in the randomized controlled trial of BMI were retrospectively classified as belonging to either the pDWI or MIXED phenotypes. Then, analyses tested 2 main hypotheses: (i) MIXED classification is associated with poorer alcohol misuse outcomes over 6- and 12-month follow-ups and greater recidivism risk over 5-year follow-up compared to pDWI classification, regardless of their intervention exposure; and (ii) the effect of BMI for curtailing alcohol misuse and recidivism risk is superior for offenders classified as pDWI than for offenders classified as MIXED. Overall, the results of this secondary analysis would indicate whether the pDWI/MIXED phenotypic classification could

inform our understanding of DWI recidivism risk and intervention outcome.

MATERIALS AND METHODS

The design, recruitment, attrition, randomization procedures, intervention conditions, blinding, integrity monitoring, and complete flow-through of the final sample are described in detail in 2 previous reports (Brown et al., 2010; Ouimet et al., 2013). A summary is provided below.

Study Recruitment and Present Sample

The Research Ethics Board of the Douglas Hospital Research Centre approved of and oversaw study procedures. DWI offenders were recruited between July 2005 and January 2007 for a double-blind, randomization controlled trial to assess the effectiveness of BMI and an IA comparator for reducing alcohol misuse and DWI recidivism over a 5-year period. Recruitment was carried out through media advertisements, invitation letters included in correspondence between Quebec's licensing agency to DWI offenders, and word-of-mouth. The main inclusion criteria for the parent study were as follows: (i) aged ≥ 18 years; (ii) convicted for at least 2 DWI offenses within the last 15 years, corroborated by Quebec licensing agency's driving records;¹ (iii) alcohol problems in the previous 6 months indicated at initial screening via an Alcohol Use Disorders Identification Test (AUDIT) score ≥ 8 ; (iv) residing within 100 km of Montreal; and (v) no current involvement in DWI intervention. Exclusion criteria were as follows: (i) academic achievement < 6 th grade; and (ii) medical or psychiatric conditions contraindicating participation. Participants received \$70 CDN following completion of the initial in-person evaluation and intervention session, and another \$70 CDN following in-person 6- and 12-month follow-ups. The present study involved 184 participants who were randomized to intervention (BMI, $n = 92$; IA, $n = 92$) and assessed at 6- and 12-month follow-ups. Of these, 180 participants were successfully tracked up to 5 years postrandomization via their provincial driving records.

Measures

Substance Misuse, Personality, and Risky Driving Intake Characteristics. The AUDIT (Conley, 2001; Saunders et al., 1993), Drug Abuse Screening Test (DAST) (Lapham et al., 1995; Skinner, 1982), Michigan Alcoholism Screening Test (MAST) (Mischke and Venneri, 1987; Selzer, 1971), and the MacAndrew Alcoholism Scale Revised (Mac-R) from the Minnesota Multiphasic Personality Inventory-2 (Butcher and Williams, 2009; Cavaiola et al., 2003) were used for sample description and typological classification. While the AUDIT, MAST, and DAST are common alcohol and drug screening instruments in research and clinical settings, the Mac-R provides information relevant to the cognitive (i.e., reward sensitivity, sensation seeking), risk taking, and externalizing characteristics frequently concomitant to substance misuse (Cavaiola et al., 2003). Risky driving excluding DWI in the past 12 months was measured for descriptive and classification purposes using an 18-item, 7-point Likert scale questionnaire (e.g., passing on the right; exceeding posted speed limits, being a passenger of a vehicle driven by an impaired driver) (adapted from Donovan, 1993). The sample's calculated mean score showed convergent validity with the number of

documented traffic crashes obtained from Quebec's licensing administration in the previous 5 years, $r^2 = 0.16$, $p = 0.01$.

Dependent Variables. Alcohol misuse, a main dependent variable, was assessed by the Timeline Followback (TLFB) (Sobell et al., 2003) at baseline and 6- and 12-month follow-ups posttreatment, specifically, percentage of risky drinking days (i.e., ≥ 3 standard drinks for males, ≥ 2 standard drinks for females) in the prior 180 days. This level of consumption, approximately 20 to 40 g of alcohol per day (i.e., $\approx 1\frac{1}{2}$ to 3 standard drinks), is associated with significant increase in alcohol-impaired crash risk (Taylor and Rehm, 2012). For analyses, transformation of percent of risky drinking days to change scores from intake to 6- and 12-months follow-ups was used. Our second main dependent variable, long-term recidivism, was gathered via participants' driving records, obtained with participant consent and with the cooperation of Quebec's licensing agency. Recidivism was operationalized as a subsequent documented DWI violation event (if any) occurred during the approximately 5-year follow-up period ($M = 1,558$ days, range = 25 to 1,995 days). Follow-up duration varied between participants by the date of recruitment into the study and the fixed study termination date.

Procedures

Interventions. Based upon random assignment, participants received one 30-minute session of BMI or IA. BMI (Miller and Rollnick, 2002) involves an empathic communication style that attempts to acknowledge and resolve patient ambivalence and evoke intentions to change behavior, while simultaneously encouraging self-efficacy and flexible coping strategies. The control IA session mimicked the time and attention paid to participants in BMI, but without its putative therapeutic elements. Instead, it consisted of gathering alcohol use-related information from participants and providing information in a didactic manner on the individual risks of alcohol misuse and DWI, and advice to reduce alcohol misuse. Interventions were provided by 3 graduate psychology students. Authors MD and FC, experienced MI practitioners and trainers, monitored BMI fidelity using the MITI-2 (Moyers et al., 2005) and supervised experimental clinicians. The main findings of the parent study pointed to the superiority of BMI over IA in reducing alcohol misuse over 1-year follow-up (Brown et al., 2010) and in reducing all traffic violations including DWI over 5-year follow-up in the youngest age tertile of the sample (< 43 years old) (Ouimet et al., 2013).

pDWI/MIXED Classification Criteria and Validation. Individual items from intake measures used in the parent randomized controlled trial (Brown et al., 2010) were selected a priori based on their availability and relevance to the alcohol, personality, and cognitive characteristics associated with the pDWI and MIXED behavioral phenotypes reported in Brown and colleagues (2016). Classification into behavioral phenotypes in that study used the following algorithm: pDWI: [≥ 2 DWI convictions at a BAC > 80 mg/100 ml OR ≥ 1 DWI conviction at a BAC > 150 mg/100 ml] AND [no other nonalcohol traffic offenses in the last 10 years]; MIXED: [≥ 1 DWI convictions in the past 10 years] AND [≥ 1 moving traffic violation (s) in the previous 2 years]. The available measures included the AUDIT, DAST, MAST, and the Mac-R. Two affiliate researchers independently coded every item within these measures based upon coherence with the characteristics of each phenotype. Significant interrater reliability was found for both the MIXED ($\kappa = 0.94$, $p < 0.01$) and pDWI ($\kappa = 0.93$, $p < 0.01$) phenotype measures. Selected items were then assessed for internal consistency, and items were discarded which reduced the overall reliability of the measure in a stepwise procedure. The items used for each classification are included in Table 1.

¹In Quebec, DWI is a criminal offense. Arrest for DWI requires probable cause, while conviction requires evidence of impairment (e.g., positive roadside test, BAC $> 0.08\%$, and/or refusal to provide a breath test).

Table 1. Criterion Variables for Classification into pDWI and MIXED

Criterion measures	
pDWI	MIXED
Alcohol misuse	Substance misuse-related aggression
AUDIT total score	MAST
Cognitive effects	• “Have you got into physical fights when drinking”
Mac-R	DAST
• “I have had periods in which I carried on activities without knowing later what I had been doing”	• “Have you gotten into fights while under the influence of drugs”
• “I frequently notice my hand shakes when I try to do something”	Drug misuse
• “I cannot keep my mind on one thing”	DAST Total score
• “I have more trouble concentrating than others seem to have”	Externalizing behavior
	Mac-R
	• “I was suspended from school one or more times for bad behavior”
	• “I have at times been rough with people who were rude or annoying”
	• “In school I was sometimes sent to the principle for bad behavior”
	DAST
	• “Have you engaged in illegal activity in order to obtain drugs?”
	Nonalcohol related risky driving
	• “I have driven while using a cell phone”
	• “You were ready to slow down at a stop sign without stopping completely”

AUDIT, Alcohol Use Disorder Identification Test; DAST, Drug Abuse Screening Test; Mac-R, Minnesota Multiphasic Personality Inventory-2 MacAndrews Scale; MAST, Michigan Alcohol Screening Test; MIXED, offenders engaging in DWI and other traffic violations; pDWI, primarily engaging in driving while impaired.

Continuous measures were then converted to a 0 to 1 metric using median split ((n/2)th), where th indicates the (n)th number in the set. All items, having equivalent metrics, were subsequently added. Total scores for each classification measure were then converted to their z-score. Next, lead author (NM-K), who was blinded to individual participant intervention allocation and their outcomes in the parent studies, classified each participant based upon the higher score on the pDWI and MIXED measures (pDWI, $n = 97$; MIXED, $n = 87$).

Internal consistency of items within each classification variable was determined using Cronbach's alpha, which indicated a mean correlation in all possible split-half divisions of $\alpha = 0.73$ for MIXED, and $\alpha = 0.64$ for pDWI. The construct validity of these variables was then addressed via concurrent association with relevant criteria not included in classification. For instance, membership in pDWI was positively correlated with MAST scores ($r = 0.33$, $p < 0.05$), consistent with alcohol use problems characteristic of the pDWI phenotype. Membership in MIXED, in contrast, was positively correlated with past 3-month cocaine use from the TLFB measure ($r = 0.19$, $p < 0.05$), indicative of drug use involvement characterizing the MIXED phenotype. Table 2 provides more comprehensive results of these analyses.

Finally, t -tests compared self-reported driving behavior between subtypes generated from the present sample to consider whether their behavioral distinctiveness was coherent with that found between phenotypes in Brown and colleagues (2016). For example, tests indicated that MIXED offenders engaged in more risky driving

Table 2. Pearson's Correlation Between pDWI and MIXED Classifications and Individual Items and Test Scores

Typology classification	pDWI ($n = 97$)	MIXED ($n = 87$)
Alcohol misuse		
MAST scores	0.329**	-0.092
Risky drinking days (TLFB)	0.176*	0.040
Percent risk of consequences (TLFB)	0.198**	0.047
Drug misuse (TLFB)		
Days of drug use	0.037	0.298**
Consecutive days using drugs	-0.009	0.199**
Cocaine	-0.070	0.186**
Cannabis	-0.051	0.143*
Stimulants	-0.029	0.213**
Sedatives	0.126	0.138*
Use of alcohol with drugs	0.072	0.279**
Risky driving		
Driving at very high speed	0.128	0.261**
Moving faster than other drivers	0.010	0.230**
Passing on the right	0.099	0.288**
Driving 10 to 20 km/h over limit	0.120	0.164*
Driving hours without break	0.121	0.194**
Driving in poor weather	0.098	0.202**

MAST, Michigan Alcohol Screening Test; MIXED, offenders engaging in DWI and other traffic violations; pDWI, primarily engaging in driving while impaired; TLFB, Timeline Followback.

* $p < 0.05$, ** $p < 0.01$.

behaviors than pDWI group drivers; MIXED drivers were significantly more likely to illegally overtake cars by passing on the right than pDWI drivers, $t(1,179) = 2.43$, $p < 0.05$, $d = 0.74$.

Analytic Strategy for Hypothesis Testing. To test the hypothesis of an association between pDWI/MIXED classification in alcohol misuse outcomes irrespective of intervention assignment, 1-way Analysis of variance (ANOVA) compared the effect of phenotypic classification on change in percent of risky drinking days from intake to 6- and 12-month follow-ups separately, with alpha for inferences of statistical significance set at $p < 0.025$ (1-tailed, given the directionality of hypothesis) for each analysis. Survival analysis (e.g., Cox regression) examined whether phenotype predicted latency to a subsequent documented recidivism event during an approximately 5-year follow-up. Alpha for inferences of statistical significance was set at $p < 0.05$ (1-tailed) for this analysis.

To test for selective intervention responsivity, a planned contrasts approach was used (Kirk, 2013). Two orthogonal planned comparisons tested our hypothesis with respect to alcohol misuse and recidivism risk, namely: (i) pDWI-BMI > MIXED-BMI; and (ii) pDWI-IA > MIXED-IA. The selection of these contrasts was based on the clinically relevant premise that phenotypic classification is associated with better outcomes to a specific intervention. The main rationale for a planned comparison approach was to increase the power of secondary analyses by avoiding an omnibus post hoc approach (Ruxton and Beauchamp, 2008) that would test a known main effect of intervention (i.e., BMI > IA) already undertaken in previous work (Brown et al., 2010; Ouimet et al., 2013) and thus were of no interest here, and interaction effects of no interest (i.e., pDWI-BMI vs. MIXED-IA; pDWI-IA vs. MIXED-BMI). Accordingly, 2 sets of these contrasts tested change in alcohol misuse at 6- and 12-month follow-ups, with alpha for inferences of statistical significance set at $p < 0.025$ (1-sided) for each comparison. Similarly, survival analyses tested the 2 hypothesized functions associated with recidivism, namely pDWI-BMI > MIXED-BMI, and pDWI-IA > MIXED-IA, with alpha for inferences of statistical significance for each set at $p < 0.05$ (1-sided). Sensitivity analyses would test the effect of potential confounders on results. All analyses were undertaken using SPSS™ v24 (IBM Corp., Armonk, NY).

RESULTS

Sample Description

When phenotypic classification was super imposed on random allocation of the sample to either BMI or IA, 4 subgroups were identified: MIXED-BMI, *n* = 45; MIXED-IA, *n* = 42; pDWI-BMI, *n* = 46; and pDWI-IA, *n* = 51. Table 3 summarizes the sociodemographic, driving history, and substance use variables of the 4 subgroups. ANOVA was undertaken to identify differences by participant categories. Expected differences between phenotypes were uncovered on variables used for classification. However, there was an age difference, with MIXED being younger than pDWI (*M* = 43.2, *SD* = 8.8 vs. *M* = 47.6, *SD* = 8.2; *p* = 0.001). Hence, the effect of this difference on the results would be appraised via sensitivity analysis using age as a covariate.

Association Between pDWI/MIXED Classification and Outcomes

ANOVA compared change from intake in percentage of risky drinking days at 6- and 12-month follow-ups by classification. The assumption of homogeneity of error variances of 6- and 12-month outcomes for the 2 classifications was met. No significant effect was detected at either 6-month (*M* = -8.7, *SD* = 24.7 vs. *M* = -9.8, *SD* = 27.4; *F*(1, 181) = 0.003, *p* = 0.48) or 12-month (*M* = -11.8, *SD* = 27.7 vs. *M* = -10.2, *SD* = 30.6; *F*(1, 181) = 0.03, *p* = 0.44) follow-ups. Model reestimation with age as a covariate did not alter these results. Regarding recidivism, a DWI violation event during the follow-up period was recorded in 17 participants (9.4%) overall, 5.2% in pDWI and 14.5% in MIXED. The cumulative hazard functions for both classifications are depicted in Fig. 1. Survival analysis with stepwise forward

entry of age and classification derived a parsimonious predictive model with only classification entered, $\chi^2(1) = 4.5$, *p* = 0.02, *exp*(β) = 2.9, 95% CI [1.0, 8.3], predicting that latency in days to recidivism violation was significantly shorter in MIXED, *M* = 1,772, *SE* = 61.5, 95% CI [1,652; 1,893], compared to pDWI, *M* = 1,907, *SE* = 37.2, 95% CI [1,835; 1,981]. Age did not add significantly to the model.

Association Between pDWI/MIXED Classification and Responsivity to Intervention

Figure 2 depicts untransformed data on percent alcohol risky drinking days at intake, 6- and 12-month follow-ups

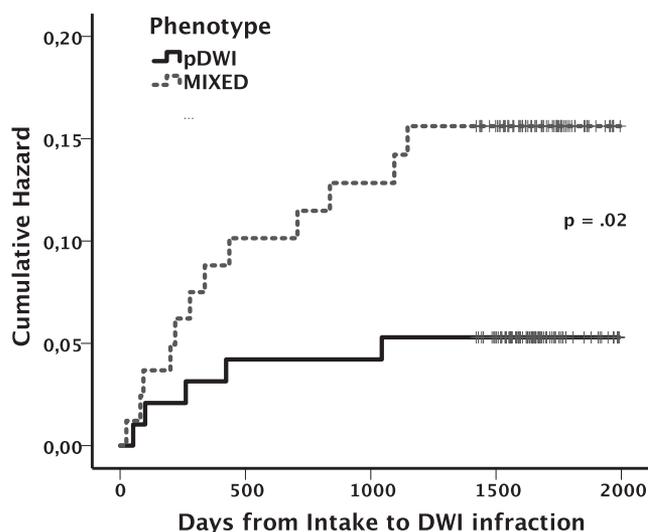


Fig. 1. Cumulative hazard to recidivism in days for the pDWI (*n* = 97) and MIXED (*n* = 87) groups.

Table 3. Participant Demographics, Driving and Substance Use at Intake by pDWI and MIXED Classification and Intervention Allocation (BMI, IA)

	pDWI-BMI (<i>n</i> = 46)		MIXED-BMI (<i>n</i> = 45)		pDWI-IA (<i>n</i> = 51)		MIXED-IA (<i>n</i> = 42)	
	<i>M</i> (%)	<i>SD</i>	<i>M</i> (%)	<i>SD</i>	<i>M</i> (%)	<i>SD</i>	<i>M</i> (%)	<i>SD</i>
Demographics								
Age	47.4	10.4	44.2	8.2	48.1	7.5	41.5	8.1
Male sex	(88.9)		(93.9)		(91.7)		(82.2)	
Education (years)	13.0	2.9	12.6	2.9	12.6	2.9	12.8	2.6
Annual revenue								
0 to 11,999	(29.2)		(30.6)		(35.2)		(28.8)	
12,000 to 29,999	(37.5)		(32.6)		(29.7)		(31.1)	
>30,000	(33.3)		(36.8)		(35.1)		(40.1)	
Driving								
Number of prior DWI offenses	4.3	2.6	3.5	1.8	4.2	2.9	3.8	3.5
Self-reported risky driving score	55.6	18.7	58.7	15.9	51.8	14.3	61.2	18.6
Substance use								
AUDIT	25.7	8.0	17.8	7.7	23.4	7.6	18.3	7.9
MAST	73.4	49.5	50.0	48.5	51.3	32.5	49.4	45.4
DAST	3.5	4.4	6.4	6.3	2.8	3.9	8.7	6.7
MMPI-Mac	5.3	5.3	20.7	5.5	20.4	6.1	22.2	6.9

AUDIT, Alcohol Use Disorder Identification Test; BMI, brief motivational interviewing; IA, information and advice control condition; MAST, Michigan Alcohol Screening Test; DAST, Drug Abuse Screening Test; MIXED, offenders engaging in DWI and other traffic violations; MMPI-Mac, Minnesota Multiphasic Personality Inventory-2 MacAndrews Scale; pDWI, primarily engaging in driving while impaired.

for all subgroups. The assumption of homogeneity of error variances of 6- and 12-month outcomes for the 4 subgroups was met. Comparisons on 6-month outcomes between pDWI-BMI ($M = -8.1$, $SD = 3.9$) and MIXED-BMI ($M = -9.3$, $SD = 3.9$) failed to detect a significant effect of classification on 6-month outcomes with BMI, contrast estimate = -1.2 , $SE = 5.3$, $p = 0.84$, or between pDWI-IA ($M = -10.0$, $SD = 24.1$) and MIXED-IA ($M = -10.2$, $SD = 26.0$), contrast estimate = -1.4 , $SE = 5.7$, $p = 0.80$. Comparisons on 12-month outcomes between pDWI-BMI ($M = -16.6$, $SD = 29.2$) and MIXED-BMI ($M = -11.2$, $SD = 29.7$) failed to detect a significant effect of classification with BMI, contrast estimate = -5.2 , $SE = 6.2$, $p = 0.40$, or on 12-month outcomes between pDWI-IA ($M = -7.5$, $SD = 25.8$) and MIXED-IA ($M = -9.2$, $SD = 31.9$), contrast estimate = -1.8 , $SE = 6.3$, $p = 0.77$. Model reestimation with age as a covariate did not alter these results.

Figure 3 depicts the cumulative hazard functions for all subgroups. Survival analysis contrasting pDWI-BMI with MIXED-BMI with stepwise forward entry of age and classification derived a significant predictive model with only classification entered, $\chi^2(1) = 4.2$, $p = 0.04$, $\exp(\beta) = 6.7$, 95% CI [0.8, 56.0], with significantly longer latency in days to recidivism with pDWI-BMI, $M = 1,949$, $SE = 41.6$, 95% CI [1,868; 2,030], than with MIXED-BMI, $M = 1,748$, $SE = 86.7$, 95% CI [1,578; 1,918]. Contrasting pDWI-IA, $M = 1,871$, $SE = 58.8$, with MIXED-IA, $M = 1,775$, $SE = 85.8$, resulted in a nonsignificant test, $\chi^2(1) = 1.1$, $p = 0.29$. Age was not significantly predictive in either model.

Sample Representativeness

Comparisons between DWI offenders attending Quebec’s administrative relicensing program ($N = 8,695$) from 2005 to 2007 and the present sample were undertaken to inform appraisal of the study sample’s representativeness and the

generalizability of the findings. The results indicated that the age of offenders seeking relicensing was younger than that of the present sample, $M = 38.9$, $SD = 13.7$ versus $M = 46.1$, $SD = 8.8$, but was similar in the proportion of male sex, 85% versus 90%, and in the percentage of drivers who were reconvicted during a 5-year follow-up period, 9.6% versus 9.4%. The mean AUDIT and MAST scores in offenders seeking relicensing were considerably lower than that observed in the present sample, namely, $M = 3.8$, $SD = 2.8$ versus $M = 20.7$, $SD = 9.0$, and the MAST, $M = 4.1$, $SD = 4.6$ versus $M = 54.8$, $SD = 44.6$, for the AUDIT and MAST, respectively.

DISCUSSION

The present study sought to extend previous research suggestive of DWI subgroups with distinct risk-taking characteristics akin to behavioral phenotypes (Brown et al., 2016). Along these lines, the clinical meaningfulness of the pDWI/MIXED classification identified in that study was appraised by testing hypotheses related to both prognostic severity and selective intervention responsivity. Overall, our hypotheses were partially supported. The results indicated that MIXED classification predicted poorer prognosis for recidivism over an average 5-year duration compared to the pDWI classification. Specifically, the MIXED classification was associated with an approximately 3-fold greater risk for earlier recidivism compared to the pDWI classification. Additionally, the findings provide evidence for selective intervention responsivity. BMI exposure in offenders classified as pDWI was associated with longer latency to recidivism compared to BMI exposure in offenders classified as MIXED over this same duration, while exposure to IA was not associated with classification-based differences in recidivism. When

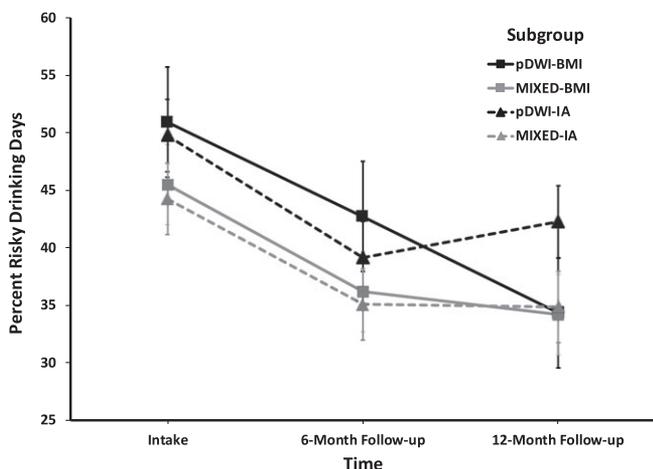


Fig. 2. Percent risky drinking days (i.e., ≥ 3 standard drinks for males, ≥ 2 standard drinks for females) in the previous 6 months at baseline and at 6- and 12-month follow-ups for pDWI-BMI ($n = 46$), MIXED-BMI ($n = 45$), pDWI-IA ($n = 51$), and MIXED-IA ($n = 42$).

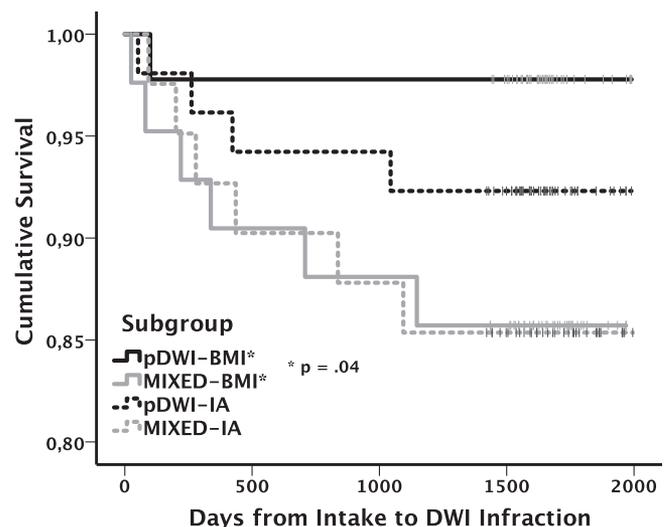


Fig. 3. Cumulative survival to recidivism in days for pDWI-BMI ($n = 46$), MIXED-BMI ($n = 45$), pDWI-IA ($n = 51$), and MIXED-IA ($n = 42$).

considering alcohol misuse outcomes at 6- and 12-month follow-ups however, the results did not support our hypotheses.

Longitudinal studies into non-self-reported risk factors for DWI recidivism are sparse and have frequently used a unidimensional approach to identifying individual characteristics linked to poorer outcomes. For example, an early study (Marowitz, 1998) found elevated risk ratios for rearrest at 1-year follow-up, namely 2.3 for arrest with BAC over 0.30% (compared to arrest with BAC at 0.10%), 1.6 for male sex, but otherwise under 1.5 for other factors (e.g., first or repeat offender status, refusal of BAC test). In a longitudinal study over 15 years, Impinen and colleagues (2009) found hazard ratios (HRs) for recidivism that, compared to the effect of a previous DWI violation, were 2.4 and 2.0 for arrest age of <18 years old and 30 to 59 years old, respectively, and HRs under 1.8 for drug use, multiple substance use, male sex, and time of arrest. Another study (Lapham and Skipper, 2010) with a 15-year follow-up found no individual characteristics to be predictive of recidivism. In a longitudinal study testing behavioral typologies in the DWI context based upon the generality of deviance theory, LaBrie and colleagues (2007) found no significant differences in risk of DWI recidivism based upon engagement in either DWI alone or DWI with other criminal offending. By comparison, the present phenotypic classification discerned higher risk associated with the MIXED classification over a 5-year follow-up, with a HR of 2.9. Thus, while certain individual variables have been associated with increased recidivism risk in the literature, the highest effect size detected (i.e., HR = 2.4 for arrest age of <18 years old; Impinen et al., 2009) is surpassed by that associated with the present phenotypic classification. Importantly, the prognostic significance of nontraffic criminal behavior is inconclusive. Overall, the present findings suggest that phenotypic classification based on traffic behavior adds much needed specificity to the prediction of DWI recidivism risk and the identification of potential intervention targets.

From an applied perspective, an offender's risk for future DWI recidivism often represents the principal basis upon which administrative relicensing and intervention decisions are made. Nevertheless, significant uncertainty plagues the assessment and characterization of DWI risk in the relicensing context. In part this is due to the frequent reliance on self-report measures of substance use and engagement in risky behavior. In this setting, such measures are vulnerable to bias by offenders motivated to present themselves in an overly positive light in order to avoid being mandated to more intensive and potentially costlier remedial programs (Cavaiola, 2013; Nadeau et al., 2016). In contrast, pDWI/MIXED classification involves objective indices accessible to traffic authorities and a relatively simple behavioral algorithm to derive (as described in Brown et al., 2016). If the present findings prove robust with replication, phenotypic classification based on traffic behavior may be a viable strategy for increasing objectivity in prediction of DWI recidivism risk and referral to an appropriate intensity of intervention.

Regarding referral to intervention, the findings speak to the selective responsivity to BMI in offenders classified as

pDWI. This result is consistent with previous findings indicating BMI is advantageously matched for individuals with features similar to those seen in pDWI offenders, namely low in impulsivity and novelty seeking (Feldstein Ewing et al., 2011), but with severer alcohol problems (Ouimet et al., 2014). In contrast, no evidence for selective responsivity to IA was found. IA was a control intervention in the original trial (Brown et al., 2010; Ouimet et al., 2013). Nevertheless, it arguably contains common therapeutic elements with Screening, Brief Intervention and Referral to Treatment programs that have produced reductions in substance misuse in health settings (Aldridge et al., 2017). In this light, the results suggest that BMI's effect for curtailing recidivism risk in pDWI offenders is superior to that seen with another bona fide brief intervention approach.

The findings also suggest a potential role of phenotypic classification for predicting a disadvantageous "mismatch" of BMI to offenders. While the pDWI-BMI pairing was associated with almost a 7-fold increase in latency to recidivism compared to the MIXED-BMI pairing, the extent of the latter mismatch is suggested in the visual trends in survival functions of the 4 subgroups (see Fig. 3). Recidivism risk associated with the MIXED-BMI pairing appeared comparable to the pairing expected to be associated with the poorest outcome, namely MIXED-IA.

Observations of BMI's effectiveness over control conditions in DWI research could argue against the relevance or need for matching. However, an intervention like BMI is not straightforward to implement in the field. BMI requires clinicians willing to accept a paradigmatic shift in counseling style, and service settings equipped to provide intensive training, continual supervision and fidelity monitoring to attain and sustain adequate "MI-Spirit" and "MI-Consistent behaviors" (Apodaca and Longabaugh, 2009; Moyers et al., 2005). These exigencies can tax the finite resources of real-world DWI relicensing settings (Chanut et al., 2005; Newbury-Birch et al., 2014), especially as they are not typically specialized intervention delivery services. Under these circumstances, limiting BMI training to willing and able service providers and provision of bona fide BMI to offenders most likely to benefit are pragmatic considerations that could support BMI's sustainability in the field. Precise rates of each classification in the DWI population and among offenders seeking relicensing also remain to be clarified however. Overall, though suggestive, the present findings are preliminary and based upon secondary analyses. Replication is needed prior to their translation in the field. Optimally, a randomized controlled trial with prospective stratification by pDWI and MIXED classification, and randomization to matched (e.g., pDWI-BMI) and unmatched (e.g., MIXED-BMI) intervention conditions would more conclusively test the benefits of a tailored intervention approach for reducing DWI recidivism.

In contrast to these positive findings, analyses of drinking outcomes produced null findings. Specifically, phenotype classification provided no conclusive information concerning change

in alcohol use over time, either regardless of intervention or in interaction with intervention. It is possible that this null finding represents an artifact of the present study's retrospective, secondary analysis approach. This possibility is noted in the Limitations section below. At the same time, intriguing visual trends depicted in Fig. 3 hinting at convergence in 1-year alcohol use outcomes in pDWI-BMI and MIXED offenders suggest a hypothesis for future prospective testing: namely, that alcohol misuse mediates long-term recidivism risk in pDWI offenders, but not in MIXED offenders.

An overarching premise of behavioral phenotype research is that alterations in physiological and neuronal functioning affect the cognitive, emotional, and motivational processing impacting behavior (Waite et al., 2014). Clarification of the neurobiological substrates that moderate and mediate effective psychosocial and biological treatments represents its clinical extension (Feldstein Ewing et al., 2011; Hutchison, 2008). Fearlessness syndrome posited to underpin the MIXED classification involves diminished anxiety and fear, elevated arousal seeking and risk taking, and aggressive, impulsive, and substance misuse behaviors that frequently manifest in early childhood (Hawes et al., 2009) and continue into adulthood (Carroll et al., 2017). Marked blunting in the cortisol stress response seen in MIXED drivers (Brown et al., 2016) is thought to contribute to fearlessness in other populations via its link to amygdala hypofunction (van der Gronde et al., 2014). In other work, we have seen cortical thinning in the posterior cingulate cortex in male DWI offenders compared to controls (Dedovic et al., 2016). This adjacent structure to the amygdala is involved in moral decision making and antisocial behavior (Glenn and Raine, 2014). Thinning was found to be especially pronounced in DWI offenders with less severe alcohol misuse, suggesting an intriguing structural neural link to the distinct features associated with the MIXED classification. In sum, long-standing anomalies in frontal-limbic structures may contribute to the poorer prognosis associated with the MIXED phenotype.

What does this speculation mean for the intervention prospects of MIXED offenders? In order to be effective, a psychosocial intervention like BMI requires intact cognitive resources and self-regulatory capacities. These include the ability to imagine and weigh consequences of different courses of action, and the capacity to inhibit behaviors that appear rewarding in the short term, but ultimately fraught with greater negative consequences in the longer term (Feldstein Ewing et al., 2011). In the MIXED classification, these capacities are unable to adequately inhibit urges for arousal through risk taking. Combining long-term installation of constraint technologies like ignition interlock, which are highly effective while installed (Elder et al., 2011), with extended case management may be worthy of consideration in such cases (Miller et al., 2015). Another approach is suggested by the nascent translational neuroscience literature that proposes brain training and mindfulness interventions as a way to enhance self-regulatory capacities (Berkman et al., 2012). A hypothesis

for future testing is that these approaches are better adapted for attenuating the elevated traffic safety risks posed by MIXED offenders than psychosocial intervention strategies that rely heavily on intact behavioral control and rational self-change strategies.

Sample Representativeness

Comparisons between data gathered from the study sample and the population of DWI offenders in the relicensing environment revealed the former to be older and more heavily alcohol-involved. This age difference possibly reflects study inclusion specifically requiring recidivism, which takes time to occur and detect. At the time, a self-reported alcohol use measure (i.e., AUDIT) was significantly higher in study participants than in offenders seen in the relicensing environment. This might reflect the inclusion criteria (AUDIT score ≥ 8) for participation in the Brown and colleagues (2010) study. However, this observation may also be attributable to the demand characteristics of the real-world evaluation setting. Offenders in that setting may be more likely to minimize alcohol problems to facilitate relicensing than offenders in the research environment where no such incentive is present (Cavaiola, 2013). Recidivism rates were essentially equivalent between the overall study sample and the population of relicensing DWI offenders, however, providing partial support for the generalizability of the present findings to the real world.

Limitations

This study's strengths include use of data from a double-blinded and randomized controlled trial, extended follow-up of self-reported alcohol use (i.e., up to 12 months) and documented traffic violations (i.e., approximately 5 years) (Brown et al., 2010; Ouimet et al., 2013). Moreover, the present phenotypic classifications have been validated in the sample of the study that identified them (Brown et al., 2016) and again in a distinct sample used for the present study (Brown et al., 2010; Ouimet et al., 2013), indicating their viability.

The present study possessed several noteworthy limitations as well. As a study based upon retrospective classification and secondary analysis, it was not specifically designed to test its hypotheses. In particular, the added group factor (i.e., phenotype classification) may have reduced the sensitivity of analysis of alcohol misuse outcomes, thereby increasing the probability of type 2 error. This study used data derived from an offender sample recruited a decade ago and followed up longitudinally to 2013; traffic violation and enforcement patterns in Quebec may have changed over time. Classification of offenders relied on available yet limited data; nevertheless, the fidelity of our resulting phenotypic classification showed evidence of convergent validity with results seen in related foundational work (Brown et al., 2016). The study sampled predominantly male offenders; while reflecting the overrepresentation of males in the DWI population, it may underrepresent important sex-based differences in the pathway to DWI

behavior (Brown et al., 2015; Dedovic et al., 2016). A sample constituted of DWI recidivists was recruited, though first-time offenders represent the chief target of secondary DWI prevention programs (Brown and Ouimet, 2013). This may have reduced the ecological validity of the findings. At the same time, many if not the majority of first-time offenders may actually be first-time “caught” recidivists (Beitel et al., 2000), a contention supported by comparable elevations in recidivism rate in first-time and recidivist offenders (Rauch et al., 2010). Nevertheless, replication of the findings in a representative sample of first-time offenders is clearly needed to support the ecological validity of the findings.

Another more general limitation common to DWI research involves the uncertain generalizability of the findings to jurisdictions where the DWI prevention approach differs significantly from that of Quebec. In particular, the composition of the Quebec DWI population from which the present sample was drawn may be distinct from those of other countries with a lower BAC per se limit (e.g., 0.05%). However, our working hypothesis is that jurisdictional differences are unlikely to substantially alter the findings of this study. The behavioral phenotypes investigated here reflect individual trait-level factors that are found to influence the proclivity for different forms of asocial risk-taking, including alcohol misuse, rule breaking, illegal and/or dangerous behavior, as well as responsivity to intervention. Replication of the present findings in different jurisdictions is clearly warranted to test this hypothesis.

CONCLUSION

The clinical significance of phenotypic classification for risk assessment and targeting intervention was supported with respect to DWI recidivism. Continued investigation of this and other phenotypic formulations is indicated.

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COMPETING INTERESTS

The authors declare no conflicts of interest.

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