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Can the effect of low doses of alcohol on subjective and physiological alertness of young drivers be balanced by effort?

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Introduction

Young novice drivers have a high risk of crashes and a linear relationship has been demonstrated between blood alcohol concentration (BAC) and crash risk for this population [1, 2]. They are also over represented in crashes linked to long period of driving. Generally, it is well known that the major part of sleep (or fatigue)-related crashes takes place during the two daily periods of physiological decrease of alertness [3]. Moreover, a monotonous road environment can influence the level of alertness [4]. Thus, effort of novice drivers higher when alertness¹ is low and the lack of resources can explain this result [5].

Consequently, the aim of this work is to evaluate the combined effect of these factors of accident (alcohol and driving experience) on driving performance. The hypothesis is that an increase of effort decreases alertness, notably when drivers lack of experience or in presence of alcohol, but could be balanced by an additional effort until a certain threshold.

Experimental protocol

Fifteen young novice drivers (YND: 18 years, less than two months of driving license) and fifteen young experienced drivers (YED: 21 years, 3 years of driving license) participated in three simulated driving sessions in which BACs were randomly manipulated (0.0, 0.2 and 0.5 g/l). The order of the session was counterbalanced. Every session took place between 1:45 and 3:45 pm, around half an hour after the drink. The task consisted to drive on a circuit representing a typical highway road during 45 min and to maintain a steady speed (110 km/h) and a stable position on the right lane. After each driving session, participants filled out NASA-TLX questionnaire and Thayer checklist. Only objective alertness (EEG), self-reported alertness (Thayer) and effort (NASA-TLX) were analysed here. Generalized linear models (GLM) were applied to data, completed with correlations².

The study was granted ethical approval by the French local ethics committee and by the French Health Products Safety Agency.

Results

Results of Generalized Linear Models (GLM) showed an effect of effort on alertness

¹ Active wakefulness is necessary to pay attention while not being a sufficient condition to ensure that attention will be focused on the right object at the right time

² GLM make possible to study the relationship between a dependent variable and a set of explanatory variables that can be categorical and continuous. The indicator associated with each explicative variable and used to complete the weight of this variable in the explanatory model is the Khi square of Wald.

($\chi^2(1) = 87.78, p < .001$) and reciprocally of alertness on effort ($\chi^2(1) = 66.15, p < .001$) ($r = -.305$). Thus, when the drivers felt they were alert their effort decreased. However, the group * effort interaction ($\chi^2(1) = 19.34, p < .001$) specified that this link could be weaker for YEDs ($r = -.217$) than for YNDs ($r = -.423$).

Results of GLM also showed that YNDs' mean alertness was lower than YED one ³ ($\chi^2(1) = 8.88, p < .003$). Self-reported alertness ($\chi^2(1) = 24.06, p < .001$) and effort ($\chi^2(1) = 8.34, p < .004$) also varied as a function of group. YNDs estimated to be less alert and make more effort than YEDs (Table 1).

	YND	YED
EEG ³	5.14 (5.64)	5.9 (4.76)
Effort (Nasa)	12.42 (4.33)	12.16 (2.89)
Alertness (Thayer)	0.83 (0.55)	1.04 (0.73)

Table 1. Mean EEG index, effort and alertness as a function of experience (SD between brackets).

The interaction group * EEG index on the estimated effort ($\chi^2(1) = 4.22, p < .04$) is illustrated by a correlation for the YED ($r = -.125$) whose effort estimation increases with increasing EEG index that is with the decrease of alertness ² (Table 2).

The effect of group * alcohol interaction on EEG index ($\chi^2(2) = 7.42, p < .02$) and on effort ($\chi^2(2) = 33.85, p < .001$) specified that YEDs' EEG index with 0 and 0.2 g/l did not significantly vary but were associated to a higher alertness level than with 0.5 g/l ($p < .001$), they also made less effort without alcohol than with alcohol ($p < .001$). YNDs' EEG index was higher with 0.5 g/l than 0.0 g/l ($p < .02$), their EEG index with 0.2 g/l did not differ significantly from 0.0 g/l and 0.5 g/l, their estimated effort were significantly higher with 0.5 g/l than with 0.0 g/l and 0.2 g/l ($p < .001$) (Table 2).

YED	0.0 g/l	0.2 g/l	0.5 g/l
Mean EEG ³	4.33 (3.89)	4.19 (2.57)	7.11 (8.57)
Effort (Nasa)	10.50 (5.85)	12.82 (2.52)	13.16 (3.41)
Alertness (Thayer)	1.16 (0.64)	0.96 (0.69)	0.98 (0.89)
YND			
Mean EEG ³	5.07 (3.71)	5.89 (4.50)	6.74 (5.72)
Effort (Nasa)	12.13 (4.40)	11.73 (4.34)	13.4 (4.08)
Alertness (Thayer)	0.97 (0.73)	0.78 (0.34)	0.71 (0.45)

Table 2. Mean EEG index, effort and alertness as a function of alcohol and experience (SD between brackets).

Alcohol and alertness interacted ($\chi^2(2) = 7.43, p < .02$): it was notably with 0.5 g/l that alertness and EEG index were correlated ($r = .165$). Thus, with 0.5 g/l, the more the drivers felt themselves awake and the less they really were. The effect of alcohol * effort interaction on EEG ($\chi^2(2) = 16.45, p < .001$) specified that it was only without alcohol that the increase in effort leads to an increase in alertness ($r = -.276$).

³ Objective alertness was calculated by (alpha + theta / beta) bands of EEG. Higher is this proportion, lower is the alertness level.

Conclusion

Results indicate some balanced effect between self-reported effort and alertness. This balanced effect permits to conserve good performance whatever the level of driving experience. Effort production thus compensates lack of alertness until a certain threshold. In fact, and as postulated this relationship seems stronger for YNDs than for YEDs. Young novice drivers also consider themselves less alert than experienced young drivers, and their EEG measures actually show a lower level of physiological alertness than YEDs, result which is consistent with the extra effort they feel when they perform driving activity [5]. This higher effort is probably due to their lack of experience. They also are less able than YEDs to regulate their effort when their alertness decreases and could be more sensible to alcohol effect.

Effort only promotes alertness in the driving session without alcohol and it can be assumed that low doses of alcohol (0.2 and 0.5 g/l) do not allow to regulate the effort necessary to safety driving. Note also that with the higher dose of alcohol the more the drivers felt themselves awake and the less they really were.

These first results thus reflect a parallel between subjective and physiological alertness according to the level of experience of the drivers and a better estimation of the effort to be provided when the alertness of the drivers is weak and they are more experienced. They must however be confirmed by behavioral data but highlight the interest to study combined effect of different factors influencing driving performance.

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