

The development of drunk behaviour during evacuation

Simeon A. Doychinov¹, Anne S. Dederichs^{1,2}

¹ Dept. Civil Engineering, Technical University of Denmark

² RISE, Research Institutes of Sweden

Abstract - The intoxication of the occupants is hardly considered in the fire safety design, due to the lack of data on the subject. Recent research experiments into the influence of alcohol on evacuation have shown evidence that there might be a correlation between the development of drunk behaviour and the surroundings or context in which the occupants are situated. That is why the experiment in this report investigated the development of drunk behaviour in a group of people within a party environment, independently of alcohol, with the use of non-alcoholic beer as a placebo. The participants were put through 3 identical exercises, which were aimed at testing their balance, reaction times, concentration, hand to eye coordination, problem solving skills, cognitive skills and cooperation. In addition to that they performed 2 evacuations that were used to interrupt their 'drunk behaviour' and test their reaction, decision and overall evacuation times. They were also analysed for signs of drunk behaviour with video and sound recordings. The results showed clear reduction of performance in the tests for concentration, hand to eye coordination, problem solving skills, cognitive skills and cooperation after the consumption of the beer, but little change in the balance tests. Apart from that, some of the participants showed signs of drunk behaviour, such as playfulness and increase in noise after the alcohol was consumed and these were reduced after the environment changed. Based on this it was concluded that even with non-alcoholic beer some of the participants developed drunk behaviour, like that observed in previous experiments with the use of alcohol.

Keywords: evacuation, drunk behaviour, placebo, experiment, fire safety

1. Introduction

Fires at venues where alcohol is consumed have had high consequences in terms of loss of human life and some of the deadliest ones on record have occurred in recent years [1]. Large amounts of people tend to concentrate at such places, and these go beyond night clubs and bars. People number in the thousands at football stadiums, for example, such as the Bradford City stadium where a fire claimed the lives of 56 people, while some of the intoxicated crowd were seen laughing and many moving or standing by with their drinks in their hands [2].

The risks at such places are further increased due to the higher possibilities of reckless behaviour by the participants when they are under the influence of alcohol. Despite this, intoxication of the occupants is not considered in the design process for areas and rooms where alcohol consumption is expected, mainly due to the lack of data on the subject. Consequently, the venues that serve alcohol today might pose a greater risk than is currently expected even if they follow current fire safety regulations.

Recent research experiments into the influence of alcohol on evacuation at DTU have given some new insights and raised many new questions [3] [4]. They have shown evidence that there might be a correlation between the development of drunk behaviour and the surroundings or context in which the occupants are situated. If this correlation is found to be significant enough, it could be used to improve the reliability of further research into the subject and to develop useful methods of crowd control for intoxicated people. That is why the experiment which this report analyses investigates the development of drunk behaviour in a crowd of people within a party environment, independently of alcohol, with the use of non-alcoholic beer as a placebo.

1.2. Knowledge on the effects of alcohol on human behaviour

The lack of research on the effects of alcohol is not isolated to the field of fire safety. As described in [5], research into the effects of alcohol on human behaviour has for a long time had its progress impaired by the disproportionate focus on problems like violence, affecting only a small minority of drinkers, while the study of 'normal' drinkers has been neglected.

A large contribution to this is the fact that nations with a strong temperance tradition and ambivalent attitudes towards alcohol have dominated the field of alcohol studies, while cultures in which drinking is not perceived as a problem have seen little need to conduct extensive research on the subject, as observed by [6].

Nevertheless, there is some useful research that sheds some light on the various effects alcohol could have on people. Both comparative studies and controlled experiments have demonstrated that, while ethanol produces well-understood neurochemical changes, the wide variations in social and behavioural outcomes of drinking can mainly be explained with reference to cultural factors, and to culturally determined beliefs about the effects of drinking [7-13].

1.3. Previous research

Research at DTU on the influence of alcohol on evacuation is still in its early stages and it has predominantly provided insight on the research methods to be used for organizing experiments.

Each experiment has been built on the previous ones and expanded the knowledge on participant behaviour. The current experiment uses insights from its predecessor "Reaction and decision time of evacuees, A study regarding the influence of alcohol on the reaction and decision time" by Poul Brinck Rask [3] and both rely on data obtained from an experiment from 2015, which compares participants performing tests under the influence of alcohol and while wearing Fatal Vision® Impairment Goggles, which simulate drunkenness [4]. Madsen and Hansen give convincing evidence that participants behave differently while wearing the goggles compared to when they are under the actual influence of alcohol.

That is why the experiment by Rask used alcohol to obtain its results. These results indicate that the participants' level of intoxication might be significantly influenced by their surroundings, which raises the question whether a certain level of alcohol intoxication by itself might not be enough to cause drunk behaviour. Therefore, this latest experiment investigates the influence of surroundings on the development of intoxication with the use of placebo alcohol.

All of these research experiments use testing methods that are connected to evacuation of buildings in different ways in order to provide further knowledge on the topic, along with knowledge on the behaviour of people.

1.4. Objective

The experiment from this report investigated the development of drunk behaviour in people as a consequence of the setting and context of the situation they are in. To do that, it was devised in such a way as to assess how the occupants' mental states are changing, what makes them change and what are the consequences of that in relation to the evacuation process. This is done by recreating a party-like environment, like that of a night club or bar, while serving non-alcoholic beer and observing its effects on volunteers and how they are affected when the environment changes.

2. Methods and Experiment Set-up

To accomplish the objective the experiment environment was set up to facilitate a mood of intoxication for the participants, similar to that of a party or a bar; non-alcoholic beer was served. The participants were only briefly brought out of this environment with two evacuations. They performed exercises chosen to measure their coordination, concentration, reaction times, cooperation and balance and were recorded with cameras with audio recording.

The participants were volunteer students from DTU campus. They were of various nationalities and their ages ranged from 19 to 37, although the majority were between 21 and 28 years old. This was a characteristic sample of DTU students and such a mix of ages and backgrounds is a common sight at campus social events.

The experiment was run in the course of 2 hours. Each exercise served as a reference to the next one. Thus, the first exercise was not intended to be a reference to the third (Figure 1).

The goal of this experimental set-up is to have the participants complete the same tasks in 3 different mental states. The only difference between the first and the second exercise is that the second one is done after the consumption of the beer during the scheduled 30 minutes 'party time'. The first evacuation also serves as a reference to the second one and is done before the drinking. It additionally serves as a transition to the 'party time'.

The use of the evacuations as transitions is done because they force the participants to briefly move out of the test environment to interrupt their mood and make them mentally distinguish the 'party time' from the other parts of the experiment. This is especially important for the second evacuation, since it aims to interrupt the participants' drunk behaviour.

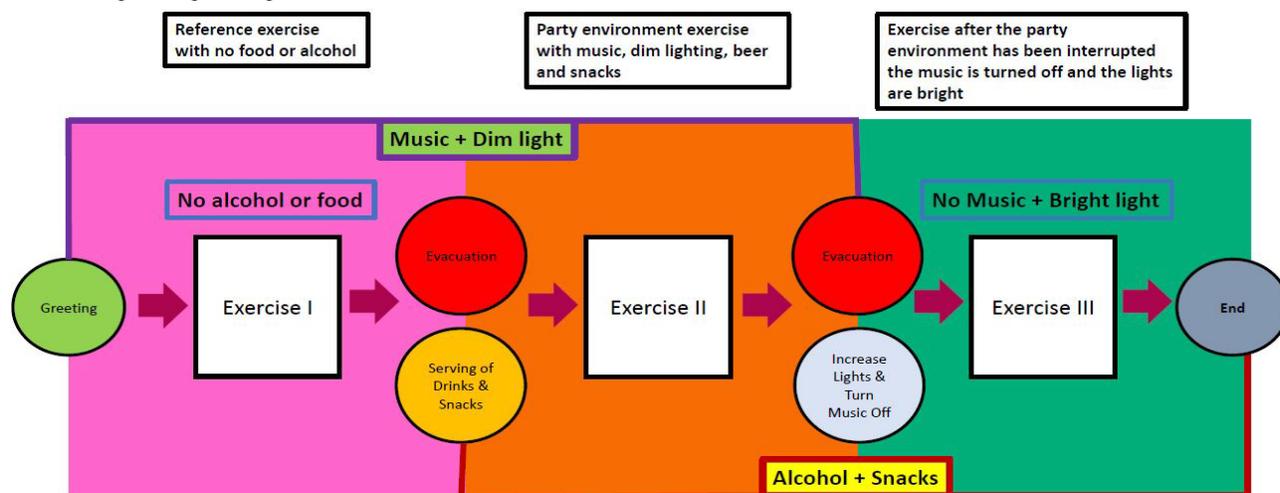


Figure 1 Experiment visualisation

Each exercise contained 3 tasks. The tasks were identical for all 3 exercises. Each participant also had to write down the amount of drinks they have had before the exercise.

The first task was to complete a printed maze of medium difficulty with a pen as fast as possible, while trying to avoid touching the maze walls. The data collected from this task was the time it took each person to complete the maze, the amount of wrong turns each person made and the amount of times they touched the walls of the maze. This type of task engages the participants' patience, cognitive process, hand-eye coordination, problem solving, concentration and, as research has shown, parts of the brain that are connected with orientation are active while solving mazes [14 -16].

The second task in each exercise was the Flamingo test. This is a popular test that requires the participants to stand on one leg for 60 seconds. Every time the person lost their balance and needed to touch the ground to restore the balance the timer was paused until the person restored the balance on one leg. The result was the number of times the person touched the ground. Additionally, it was to be noted down if the person swayed while balancing, used arms for balance or hopped; and it was encouraged to give additional comments if needed.

The third task of each exercise was the Up & Go Test. This is a test of both reaction time and balance. In it two people take turns to test each other - one of the participants sits on a chair and the other stands 2.5 m from them at a marked spot with a timer, see Figure 2.4. When the participants have assumed their

positions, the standing person gives the signal 'GO' and starts the timer, upon which the sitting person has to get up and run as fast as possible around the standing person and sit back on the chair. As soon as they have done that they should yell 'STOP'. When the signal 'STOP' is given the standing person should stop the timer and write down the recorded time. Additionally, they are encouraged to give extra comments on the performance.

The amount of people that participated in the experiment was low, so in order to make more accurate assumptions of the general population based on the data from this experiment the t score formula was used (Mason, Gunst, and Hess 2003).

The formula was applied for a two-tailed distribution of two samples with unequal variance. The final outcome of this calculation is the percentage of certainty with which it can be claimed that the two samples are significantly different. When that percentage is over 95% it is statistically safe to assume that the samples are significantly different.

The participants in the experiment were between the ages of 19 and 37, with the majority being in their mid-twenties. Therefore, they are most representative of this age group.

Another source of error is the gender ratio imbalance, similar to previous experiments. There were 3 times more men than women, so the results might be more indicative of male behaviour.

Additionally, due to the limited amount of people, the same people had to complete all the evacuations and exercises, which means that with every next repetition they gain a certain level of skill in performing them, which affects their results.

To make sure that the experiment did not violate any ethical laws, the National Scientific ethical Committee and the scientific ethical committee at Hovedstaden were provided with detailed information about it. They informed the organizers that if the experiment does not conduct medical experiments it is not required to consult them.

Furthermore, the campus services were consulted about the safety rules that needed to be followed while using the campus facilities for the experiment. Concerning the video recordings, the Danish Data Protection Agency's website states that permission from them is not needed when the data is used in a master's thesis study and with participant consent [17]. The recordings were stored according to university sensitive data storage rules.

The participants were informed about all aspects of the experiment, except the exact alcohol content of the beer. They were given an experiment timetable and were asked to sign a form of consent before participating.

6. Results and Discussion

The participants were divided into three groups based on the amount of beer they drank and whether they drank it throughout the experiment or only in the beginning of the 'drinking time'. These groups are given the names 'high beer consumption group', 'medium beer consumption group' and 'low beer consumption group' (Figure 2).

Beers	Ex2	3	5	5	6	4	5	4	2	2	2	2	2	3	2	2	3	3	3	2	2	3	3	2
	Ex3	5	6	6	8	7	6	5	3	3	3	3	3	4	3	2,5	3,2	3,5	3	2	2	3	3	2,5

Figure 2 High, medium and low beer consumption groups in green, red and blue respectively and the amount of beer each person drank by the first and by the second exercises.

6.1. Maze Task Results

Firstly, the scores from the participants were compared between the 3 groups within each exercise. The difference between the low and medium consumption groups has the highest percentages, but still 86% is the highest one. The percentages are highest in Exercise 1, before the participants consumed the drinks, and get lower with each consequent one.

After the consumption of the alcohol the standard deviations increase, which makes the certainty drop. This may mean that some people experienced the placebo effect while in others it was weaker or did not develop at all, which results in the increasingly different performance. From Figure 3 the differences between the mean scores can be seen.

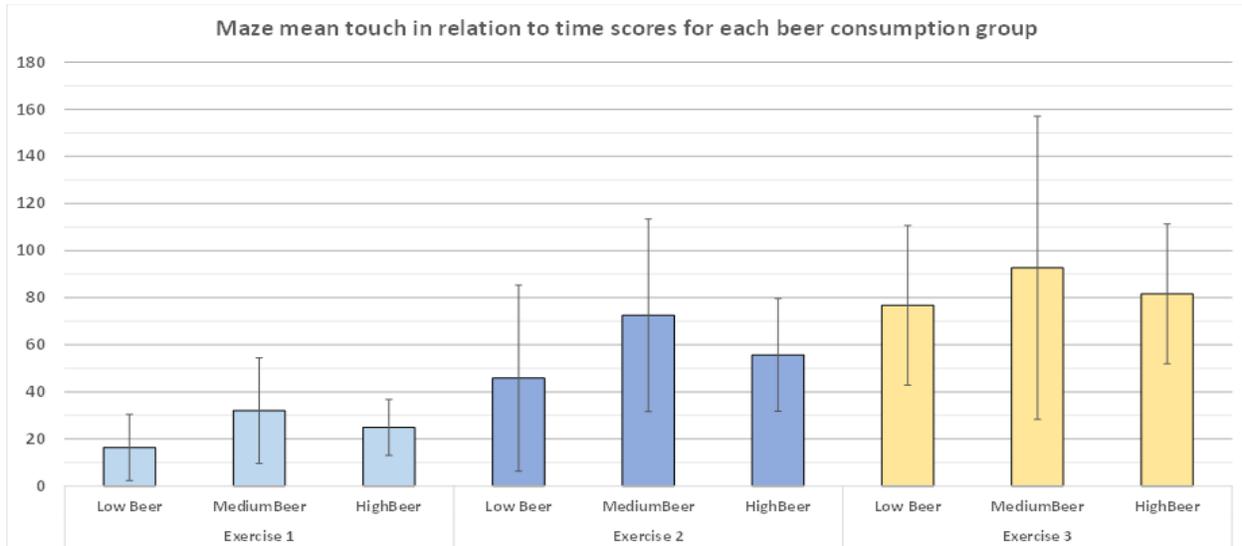


Figure 3 Maze mean touch/time results for each group in each exercise

On Figure 4 the results of each participant are displayed for each exercise based on how much beer they drank by the end with a trend line for each exercise's results. Thus, if a person drank 5 beers in total, their results of each exercise would be at 5 beers and only the scores would change. Two people failed the task in the second exercise, one of which had drank 6 beers and the other 7, so they are missing from the chart.

From the chart it can be clearly seen, that the performance of the participants is dropping as their touches increase in each consecutive exercise and the differences between them are becoming more exaggerated after the consumption of the alcohol but at the same time follow a similar curve.

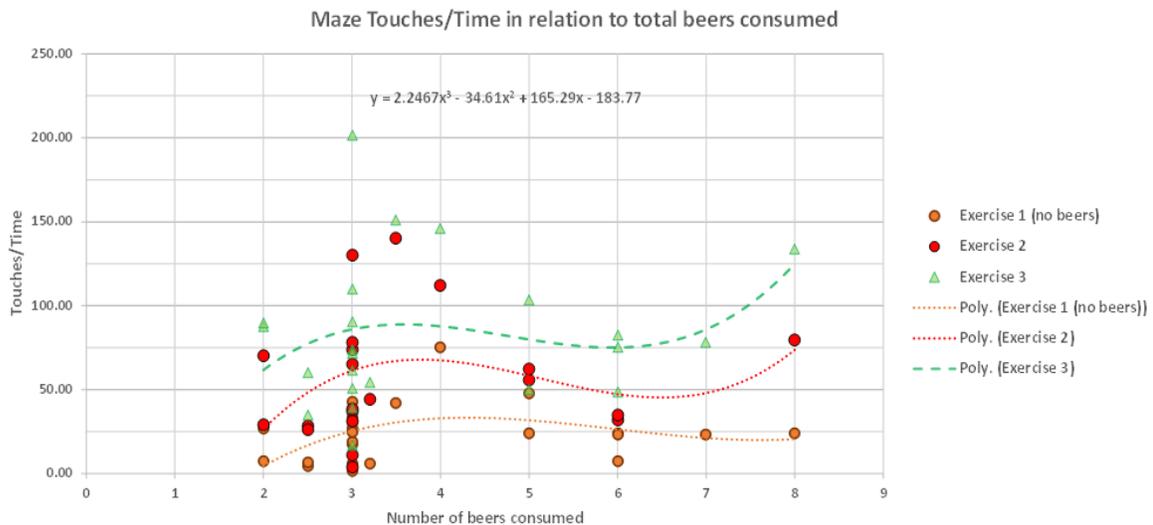


Figure 4 Maze touches per minute scores in relation to beers consumed

In another comparison, the percentages are checked for each group, comparing the group's results from exercise 1 against the results from exercise 2 and, likewise, exercise 2 against exercise 3. From these comparisons the differences in scores are much more certain when compared between exercises, especially

between the first and second exercises. The individual group performance differences between Exercise 1 and 2 are above 95% with the exception of the low consumption group, which is 94%. And when all participants are grouped together the differences are above 95% for both exercises.

From Figure 3 & Table 1 it is visible that the mean scores markedly increase with each consecutive exercise and the standard deviations follow this trend as well, except for the low beer consumption group's third exercise scores, where the deviation slightly decreases.

Table 1 Maze mean touch/time results for all people together and their standard deviations (SD)

	Mean	SD
Exercise 1	23.743	17.1
Exercise 2	56.396	36.744
Exercise 3	83.069	42.853

An additional note should be made about the two people who failed to complete the task in the second exercise. Because in this task the lower the values are the better the performance is and there is no limit to how high the values could go, there is no way to consider the failures into the statistics. That is why the failures are mentioned here separately.

The amount of wrong turns taken is highly dependent on the maze route. Thus, the amount of wrong turns per minute is calculated for each participant and then the means from these results are compared between the different groups only within each exercise.

From the t-test scores the percentages are too low for these results to be conclusive. Only in the comparison between the low and high consumption groups in Exercise 2 there seems to be a very high percentage of 93%, but still lower than the 95% certainty requirement.

What additionally should be noted about these results is that, just as in the touch/time results, the differences that were present between the groups became more pronounced, except that in this case their results are better with each consecutive exercise.

6.2. Up & Go Task Results

The times of the completion show little variation and based on the statistical analysis this variation cannot be used to prove significant differences. The participants, on average, performed the same or only slightly better every next exercise. This can be seen also in a previous experiment that was done with the use of real alcohol. It is not clear to what extent these results are because of the alcohol and to what extent because of learning, but the latter is considered the more probable.

One thing that is clear from both the previous experiment and this one is that drinking between 2 and 8 beers has little to no negative effect on the performance of the participants in this task.

Apart from the time scores of the participants this task also allowed them to make additional comments. There was only one comment in the first exercise, four in the second one and one in the third. While in the first and last exercises the single comments are strictly related to issues with the participants' performance in the task and in the case of the first exercise it was written by an assisting organizer, in the second exercise two of the comments are 'funny' comments.

This suggests not only a slightly higher rate of failure of the participants to perform in the task during the second exercise, but also a more playful and relaxed attitude among some of them.

6.3. Flamingo Task Results

In the Flamingo task the mean number of errors varies very slightly throughout the experiment for each group and at the same time the standard deviations were large, from which no significant differences could be deduced.

These results are in some ways similar to the results from Madsen and Hansen. However, in that experiment the performance becomes worse after consuming the beer, whereas in this experiment the

performance of the medium and high beer consumers worsens in the second exercise and improves in the third while the performance of the low beer consumers improves in each consecutive exercise.

6.3. Crowd behaviour and observations

During the exercises the participants tended to become quiet during the maze task, which required them to focus. During other tasks they tended to converse and make noises due to movement. This was later confirmed with an analysis of the sound recordings of the experiment.

During Exercise 1 they were generally quiet and focused on completing the exercise and the only noise they made was when asking questions on how to perform the tasks. Then, after the first evacuation, they started consuming the beer and became noticeably louder and more relaxed. Some of them started playing drinking games or just games for fun. This changed after the second evacuation. After it was complete they became increasingly quieter and focused on completing the exercise, though some of them were still noisy, especially the ones that continued to drink and drank the most. Their performance during the two evacuations was almost identical.

The magnitudes of the noise in the midst of the participants were extracted into charts and trend lines were generated. Then it was observed from the magnitudes and clearly seen from the trend line that the noise level peaks during the middle of the drinking time and subsides when Exercise 2 begins and then more when at the start of Exercise 3, although it is still higher afterwards than it was during Exercise 1. This is visible on all 3 recordings and is considered as conclusive evidence that the participants became louder with the consumption of the beers.

7. Conclusion

The experiment from this report has tested the development of drunk behaviour, without the consumption of alcohol, in a group of 23 people from a mix of cultural backgrounds for the purpose of evacuation. This was achieved by recreating a 'party-like' environment within the experiment area and using non-alcoholic beer in the hopes of inducing a placebo effect and then test whether this effect influences the participant's evacuation capabilities.

None of the participants showed any signs of suspicion about the alcohol content of the beer and the majority drank continuously throughout the second two thirds of the experiment. During that time several distinct changes were observed in them.

Firstly, the mean maze touch/time results of the participants showed reduced performance in each consecutive exercise. This points to a reduction of hand to eye coordination and focus, which could be either due to inebriation or due to a reduction in the amount of effort put to complete the task successfully. In addition to that, there was an increase in frivolity and emotional behaviour during the second exercise after the consumption of the beer, judged by the comments and notes for all tasks, some of which were irrelevant or 'funny', and two of the participants gave up on completing the task during the exercise. In one of these cases the participant scratched up the maze angrily.

Furthermore, the participants displayed increased contrast in performance, resulting in increased standard deviations after the consumption of the beer and an increase in noise level, which peaked during their drinking time and gradually decreased as the experiment was ending.

At the same time there were things that did not change after the consumption of the beer. The performance from the balance tasks and the evacuations showed little to no change or even very slight improvement, which was in some ways consistent with previous experiments that used normal alcoholic drinks to conduct similar tests.

Overall, the experiment results are in many ways similar to previous experiments with alcohol and show some definite signs of the development of drunk behaviour independently of alcohol. Additionally, there is proof that drunkenness, whether caused by alcohol or a placebo, causes significant changes in cooperation, willingness to follow instructions, focus and mood in some people and it might cause opposite effects in others. There is no proof yet that it impairs the overall group movement capabilities, but there is evidence that the decision making, and course of action of the group and individual might be significantly altered.

References

- [1] “Deadliest public assembly and nightclub fires,” *N. F. P. Association*, 2017. [Online]. Available: <http://www.nfpa.org/public-education/by-topic/property-type-and-vehicles/nightclubs-assembly-occupancies/deadliest-public-assembly-and-nightclub-fires#outside>. [Accessed: 01-Nov-2017].
- [2] FSUK, “The Bradford City Football Fire,” *Fire Service UK*, 2014. [Online]. Available: <https://web.archive.org/web/20130216013625/http://bradfordcityfire.co.uk:80/>.
- [3] P. B. Rask, “Reaction and decision time of evacuees A study regarding the influence of alcohol on the reaction and decision time, Indflydelse af alkohol på reaktions og beslutningstid i forbindelse med evakuering,” 2017.
- [4] A. Madsen and M. W. M. Hansen, “The effect of alcohol related impairment on evacuation characteristics,” 2015.
- [5] D. Morris, “Social and Cultural Aspects of Drinking,” *Rep. to Eur. Comm.*, no. March, p. 102, 1998.
- [6] K. Mäkelä, “Consumption level and cultural drinking patterns as determinants of alcohol problems,” *J. Drug Issues*, 1975.
- [7] L. T. Midanik, “Drunken comportment: A social explanation,” *Addiction*. 2002.
- [8] M. Marshall, *Weekend warriors: alcohol in a Micronesian culture*. California: Mayfield, 1979.
- [9] G. A. Marlatt and D. J. Rohsenow, “Cognitive processes in alcohol use: expectancy and the balanced placebo design,” in *Advances in Substance Abuse: Behavioral and Biological Research*, K. Mello., Greenwich: JAI Press, 1980.
- [10] H. L., D. L.J., and M. J.K., “Drinking contexts, alcohol beliefs and patterns of alcohol consumption: evidence for a comprehensive model of problem drinking. *Journal of Drug*,” no. 25, pp. 783–798, 1995.
- [11] S. Peele, “Utilizing culture and behaviour in epidemiological models of alcohol consumption and consequences for Western nations,” *Alcohol Alcohol*, 1997.
- [12] D. B. Heath, “Cultural variations among drinking patterns,” in *Drinking Patterns and their Consequences*, I. M. Grant and J. Litvak, Eds. Washington: Taylor & Francis, 1998.
- [13] H. D.B. and R. H., “Community reactions to alcohol policies,” in *Drinking Patterns and their Consequences*, I. M. Grant and J. Litvak, Eds. Washington: Taylor & Francis, 1998.
- [14] P. Kirsch *et al.*, “Brain activation during mental maze solving,” *Neuropsychobiology*, 2006.
- [15] R. W. Skelton, S. P. Ross, L. Nerad, and S. A. Livingstone, “Human spatial navigation deficits after traumatic brain injury shown in the arena maze, a virtual Morris water maze,” *Brain Inj.*, 2006.
- [16] J. D. Van Horn *et al.*, “Changing patterns of brain activation during maze learning,” *Brain Res.*, 1998.
- [17] “The Danish Data Protection Agency.” [Online]. Available: <https://www.datatilsynet.dk/english/the-danish-data-protection-agency/introduction-to-the-danish-data-protection-agency/>. [Accessed: 20-Sep-2017].