Testing training programs to limit binge drinking

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ABSTRACT

Background: Young people becoming overly intoxicated by drinking alcohol is a widespread problem with consequences ranging from hangovers to death. Previous research has shown that high school students do not know that the slow diffusion of alcohol from the stomach to the body can cause them to continue becoming more intoxicated even after they stop drinking. A natural next step is to explore training programs designed so young people will learn to avoid becoming more intoxicated than intended. Will training programs lead to better understanding, will understanding influence drinking patterns, and will changes be immediate or follow after some period of time as deeper understanding enables better interpretation of one's bad experiences?

Method: Two training programs, a simulator-based learning environment and printed information, are tested on two groups of high school students and contrasted to a control group receiving neither form of training. Students were asked to report their drinking experiences before, one month after, and two months after the training.

Results: Those who received simulator-based training made the better forecasts of the effects of drinking. Those with written information reduced their drinking relative to the control group over time. However, this result could also be explained by other factors.

*Conclusion***:** A better research design is needed. A two-week celebration period in the last month may have dominated learning effects and reflection. Learning also seems to require more time than the short interventions in this experiment.

Key Words: alcohol, binge drinking, responsible drinking, health education, overshoot behavior, misperception of dynamics, laboratory experiment, training program

1. INTRODUCTION

A large fraction of young people engages in dangerous binge drinking ranging from 20 to 67 percent in many industrialized countries (Bennette et al. 1999; Jack et al. 2005; Administration 2007). Excessive intoxication has undesired consequences varying from common ones such as embarrassment, vomiting, and hangovers to less frequent but more dangerous ones involving injury and even death from alcohol instigated fights, drowning, fires, traffic accidents, unsafe sex, rape, suicide attempts, poisoning etc. (Jones and Pounder 1998). In addition to the individual costs, societal costs in terms of health care, social and police work are considerable. In spite of information campaigns to influence drinking patterns by young people, the problem persists. Hence, more effective training programs should be welcome.

This article reports the testing of training programs that are directed at a cause of excessive drinking as earlier analyzed by Moxnes and Jensen (2009). In a laboratory experiment, they found that high school students have almost no intellectual understanding of how the consumption of alcohol into the body is delayed by the slow diffusion of alcohol from the stomach and upper intestines to the rest of the body. As a result, if they attempt to make rational drinking decisions based on their feeling of intoxication, which is influenced by the blood alcohol concentration (BAC), they are in danger of becoming more intoxicated than they had intended. In the Moxnes & Jensen study, the average high school participant ended up with a BAC level 86% above the instructed target. This result is not unique to the alcohol problem, as similar overshoots are observed in dynamically analogous systems (Moxnes 2012).

Regarding training programs, Moxnes and Jensen found that experience with a simulator improved decision-making within simulators. Access to printed information had a small but statistically insignificant effect. The very important question that still remains is whether such training programs will influence real drinking behavior, which is affected by many factors. That is the main focus of this paper. A closely related question is how to best design such a training program.

Our hypothesis is that training programs to help students understand the dynamics of alcohol will have an impact on real drinking decisions. One group of students (N_1=61) received training on a simulator, another group (N_2=75) read printed information, and a control group (N_3=61) received neither training nor information to improve understanding. All three groups were asked to report drinking experiences on a questionnaire at three different times, before the training started, one month after, and again two months after training. Their understanding of the dynamics of alcohol consumption and intoxication were also assessed on the questionnaires.

The learning effects found by Moxnes and Jensen's laboratory experiment motivated this study. When it comes to real drinking behavior, limited understanding of complex dynamics is challenged by feelings of the moment that trigger heuristics that seem rational to the drinker. Hence the quality or depth of training programs is likely to matter. For that reason we test both simulator training, presumed to be more effective, and printed material.

Evidence also suggests that learning is likely to be slow. When people do not have appropriate mental models of complex phenomena, laboratory experiments show slow learning from experience (Brehmer 1980; Brehmer 1990; Paich and Sterman 1993). Subjects in the Moxnes and Jensen's study reported only a weak reduction over time in the frequency of excessive intoxication in the time period before the experiment took place. Risky behavior and slow learning is also seen among people that start using methadone, where uptake in the body is slower than for the heroin that methadone replaces (Cornish et al. 2010). Several weeks are required before the probability of overdose and death are significantly decreased. Hence, for both alcohol and methadone, learning from experience takes time. For this reason, training effects must be observed over a substantial period of time.

Even if training programs fail to have an immediate effect on drinking strategies, they may still enable *quicker* learning. Bad experiences seem to produce "teachable moments" when available information is used and strategies are changed (Clark and Moss 2011). For this purpose, simulators and printed material may provide juveniles with different frames of reference for interpreting bad experiences. Different programs may have different long-term effects. Important to note, the understanding provided by training must compete with simple explanations, such as events that drinkers tend to correlate with bad experiences. Excessive intoxication has been attributed by subjects to external factors such as type and availability of alcohol, food intake, and mood (Moxnes and Jensen 2009). The same tendency to explain internal dynamics by external events has been observed in many dynamic systems (Sterman 1989; Moxnes 2000).

The next sections present the training simulator, the experimental design, results and conclusions.

2. SIMULATION MODEL

The model used in the simulator is identical to the model used in (Moxnes and Jensen 2009). Figure 1 shows the structure of the model where rectangles denote stocks, double lines denote flows, thin lines represent instantaneous cause and effect relationships, and circles contain functions and constants. Question marks indicate those constants for which the subjects make inputs or decisions. Symbols in the equations that follow are straightforward abbreviations of the variable names.

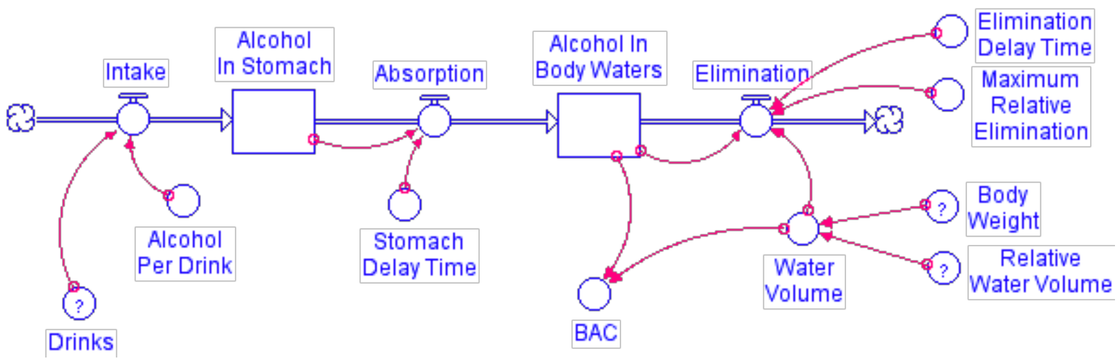

Figure 1: Stock and flow diagram of simulation model

Intake of alcohol in grams per minute

$$I = D * APD / 15\,\text{min} \qquad (1)$$

is given by the number of *Drinks* each 15 minutes times the amount of *Alcohol Per Drink* (12.25 g/drink). The amount of *Alcohol In Stomach* (grams)

$$AIS = \int (I - A)\, dt + IS_0 \qquad (2)$$

increases with the *Intake* and is reduced by *Absorption* into the circulatory system and the body's reservoir of water – measured in volume units. Initially there is no alcohol in the stomach, IS_0=0. The *Absorption* of alcohol to the blood stream from the stomach and upper intestines

$$A = AIS\, /\, SDT \qquad (3)$$

is equal to the amount of *Alcohol In Stomach* divided by the average *Stomach Delay Time* (measured in minutes).[1] For the purpose of this study the delay time (SDT=22.5 minutes) is of vital importance. The amount of *Alcohol In Body Waters* (grams)

$$AIBW = \int (A - E)\, dt + AIBW_0 \qquad (4)$$

increases with *Absorption* into the blood stream and the body's reservoir of water and is reduced by *Elimination*; $AIBW_0$=0. Most of the elimination takes place in the liver (90%), and can be modeled as

$$E = \mathrm{MIN}\ (AIBW\, /\, EDT,\ MRE * WV) \qquad (5)$$

Maximum elimination is given by the *Maximum Relative Elimination* times the *Water Volume* of the body, and is *MRE*=0.0025 g/L/min according to (Gullberg and Jones 1994). This expression approximates well the Michaelis-Menten kinetic model (Jones 2003). For small amounts of *Alcohol In Body Waters*, elimination is given by *Alcohol In Body Waters* divided by the *Elimination Delay Time*, which is *EDT*=15 minutes. This estimate is of little importance since the upper limit quickly dominates when drinking.

Water Volume of body (litres)

$$WV = BW * RWV \tag{6}$$

is the product of *Body Weight* and *Relative Water Volume*, also referred to as Widmark's factor. This factor depends on gender and is 0.6 l/kg for females and 0.7 l/kg for males (Jones and Pounder 1998). *Body Weight* and *Gender* (and hence on *Relative Water Volume*) are provided by participants at the beginning of the simulation. Finally, *Blood Alcohol Concentration* (grams per liter) is given as

$$BAC = AIBW \ / \ WV \tag{7}$$

The model provides a good description of observed data (Martin et al. 1984; Moxnes and Jensen 2009). As summarized by Moxnes and Jensen, parameters vary among individuals and with intake of different foods and drinks. This poses a problem for learning, which is inhibited by

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1 The *Stomach Delay Time* is not included in the often used Widmark's equation (Gullberg and Jones 1994), while it is implicit in the model used by (Martin et al. 1984).

variation from one experience to another. Learning is also hindered by imprecise knowledge of external and internal factors, by dynamics and nonlinearities, and by alcohol myopia. Hence, safe drinking strategies and decisions must be robust in light of uncertainty about specific conditions at any particular time.

3. EXPERIMENTAL DESIGN

Table 1 shows the experimental design. There are three treatments: T1-simulator training, T2-reading printed material, and T3-no information. Immediately after information is given, participants answer the first questionnaire, Q1, about their drinking experiences during the preceding three weeks. They also provide some personal information. After about one month, in a second session, participants answer questionnaire Q2 about their drinking experiences during the preceding three weeks. After another month, participants answer questionnaire Q3.

Table 1: Overview of experimental design

Treatment	First session		Second session	Third session
T1	Simulator training	Q1	Q2	Q3
T2	Reading printed material	Q1	Q2	Q3
T3	No information	Q1	Q2	Q3

Treatment 1: Training simulator

Students download the training simulator to their own laptops. The training simulator consists of 9 pages that participants must complete in order. The 9 pages are:

p1. Login with an assigned code to ensure participant anonymity

p2. Brief introduction with a focus on getting more intoxicated than intended

p3. Input of one's own gender and weight in kilograms

p4. A simulator challenge before the training

p5. Physiological information about uptake and elimination of alcohol

p6. First training session to observe the dynamics

p7. Second training session to experience the concept of the hidden stomach

p8. Third training session to explore a 'counting drinks strategy'

p9. A thank you page and directions to progress to questionnaire Q1

On page 4, participants are challenged to determine an appropriate number of drinks every 15 minutes to reach a goal for the blood alcohol concentration (BAC) of 0.8 grams per liter. This task is mathematically identical to the reference task in (Moxnes and Jensen 2009). There is a difference is that participants do not receive numerical information about the BAC. Rather they see the color of a person in a drawing change with the BAC. The color of the person's shorts indicates the target BAC. By using colors to indicate the BAC, the sensory system experiences something similar to sensations of intoxication and somewhat different from reading exact numbers. Based on the overshoots observed in the earlier study, the page 4 challenge is likely to surprise a majority of participants and create some cognitive conflict.

Page 5 displays a drawing of a person showing the placement of the esophagus, the stomach, and the liver within the body. On page 6, these vital organs are portrayed as two funnels, as seen in Figure 2. The text is in Norwegian as the participants were Norwegian high school students. The upper funnel represents the stomach and the lower one represents the body. Participants control the intake of alcohol in terms of how many drinks they consume during each 15-minute period. The simulator equations determine the flow of alcohol from the stomach to the body and the elimination rate through the liver. Time is shown on a clock. As can be seen from the figure, participants are given a good sense of how the alcohol is distributed between the stomach and the body. They also observe that it takes time for alcohol to move from the stomach to the rest of the body and that it stays in the body for a very long time.

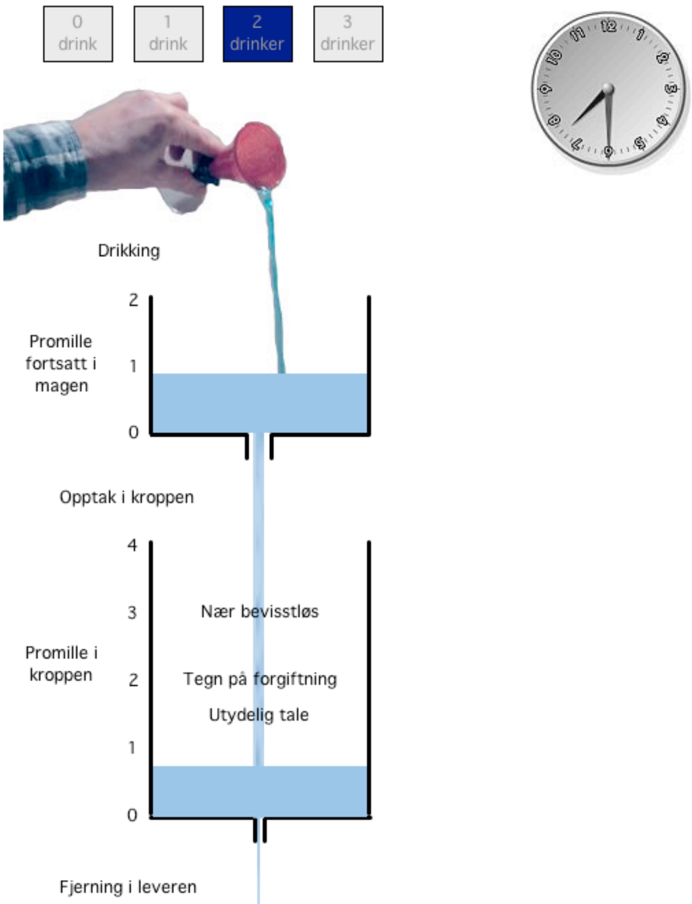

Figure 2: Simulator for training program

In the lower funnel, the scale for BAC is in per mille ("promille"), which is the standard notation in Norwegian. "Promille i kroppen" means "promille" in the body. This corresponds closely to grams per liter. The consequences of three different BAC levels are indicated by texts saying: Unclear speech ("Utydelig tale"), signs of poisoning ("Tegn på forgiftning"), and near unconscious ("Nær bevisstløs"). The upper funnel uses the same scale, and the text ("Promille fortsatt i magen") says "promille" still in the stomach.

On page 7, the walls of the upper funnel are no longer transparent. This means that direct observation of the amount of alcohol in the stomach is no longer possible, as is the case when drinking alcohol in reality. Participants are forced to explore new ways of controlling their BAC. This is a more realistic representation of the challenge people face when drinking. For this exercise the BAC goal of 0.8 grams per liter is reintroduced.

On page 8, the simulator interface is the same except that participants can set their own BAC goal before they start. The accompanying text suggests and explains the following drinking rule: *Count the number of drinks and do not drink too fast*. Then they are challenged to use the personalized simulator to practice determining an upper limit for the total number of drinks given the goal they have set for themselves. Page 9 ends the training and asks them to answer the questions in the first questionnaire, Q1.

Treatment 2: Printed information

The printed information is one page long. It contains the same paragraph that suggests and explains the drinking rule on page 8 of the simulator program. The printed page also shows Figure 2 with explanatory text.

Treatment 3: No information

Participants are given no information and start by answering the first questionnaire.

Questionnaires Q1, Q2 and Q3

Q1 consists of 10 questions (q1 to q10). Q2 consists of the first six questions in Q1 (q1 to q6). Q3 consists of the first three questions in Q1 (q1 to q3) plus three new questions for all treatments ($q_3$4 to $q_3$6) and additional three new questions for T1 and T2 ($q_3$7 to $q_3$9). The questions are the following (here translated from Norwegian):

q1. Over the last three weeks how many times have you been drunk?

q2. Over the last three weeks how many times have you been drunker than intended?

q3. Over the last three weeks how many times have you had painful and regrettable experiences due to drinking?

q4. If you have been drunker than intended or have had painful and regrettable experiences, how do you explain that?

q5. Compared to others of your age, do you drink more, equally as much, or less?

q6. How many drinks do you typically consume at parties?

q7. What do you study, science or other topics?

q8. What grade have you typically received on math tests?

q9. What is your weight, approximately?

q10. What is your gender?

$q_3$4. Many juveniles get drunker than intended, how do you explain that?

$q_3$5. How many drinks do you typically consume at parties?

$q_3$6. Assume that you drink four bottles of beer from 9 pm to 10 pm and stop drinking at 10 pm. What will your "promille" (BAC) be at 10 pm and at 10:30 pm?

$q_3$7. In the first session you received *information* about how the BAC develops when drinking. What was the main point in this information?

$q_3$8. If you have been drinking alcohol the last weeks, have you thought about this *information* when drinking?

$q_3$9. Have you discussed this *information* with others?

Participants

Student participants were recruited from three high schools in the Bergen area of Norway, near the end of the third and last school year. This is an interesting group of students since there is a tradition for partying and a lot of drinking just before the exam period starting in the last half of May. Starting with questionnaire Q1 in March, Q2 in April, and Q3 in mid May, we cover a period during which there are many occasions where students experience drinking.

Table 2: Characteristics of sample

	Sample size	Percent female	Average weight (kg)	Percent science	Average grade	Drinks/ volume	Average self -ranking
T1	61	51	68.6	43	4.2	0.186	-0.16
T2	75	67	65.1	41	4.7	0.150	-0.43
T3	61	59	64.5	56	4.0	0.177	-0.33

The sample size refers to those who finished training and answered Q1. The sample size decreased over time for all treatments and particularly for T1 in Q3. Differences between the three treatment groups are tested by Mann-Whitney U tests. There is a near significant difference between T1 and T2 in the percentage of participants who were female, $p=0.06$. The average grade in mathematics differs between T2 and both T1 and T3, $p<0.001$. For the period before participants received information, drinks per volume of body waters differed between T1 and T2, $p=0.006$, and between T2 and T3, $p=0.008$. The average self-ranking of relative drinking differed between T1 and T2, $p=0.01$. The scale is from -1 for less than average and to +1 for more than average.

Of potential importance, the group in T2 has higher grades in mathematics than the two other groups and drink less than the two other groups per volume of body waters. The average self-ranking of relative drinking is consistent with the average reported number of drinks per body water volumes. Thus, there may be confounding between the three treatments and the characteristics of participants in those treatments.

The main reason for treatments being between (rather than within) separate high schools was motivated by interactions between students within a school enabling diffusion of treatment information over time. Answers to question $q_3 9$ support this suspicion; 32% answered that they had discussed treatment information with others in both T1 and T2. The drawback of this design is the above differences between student backgrounds, and potential differences between school cultures and types of parties that the students attended during the period of the investigation.

4. RESULTS

The results are organized in the following way. First, effects on learning and understanding are explored based on recordings of the simulator training for the T1 group. Second, answers in the three questionnaires are used to study learning and understanding over all three treatments. Third, effects of treatments on drinking behavior are investigated.

4.1. Simulator results on learning

Before answering questions, participants in T1 worked with a simulator. Average and median time spent on the entire simulator task was just below 10 minutes. The first challenge was to reach a blood alcohol concentration (BAC) of 0.8 g/l after one hour of drinking. The average maximum overshoot was 81% higher than the announced goal and the median 56% higher (N=64). This result is similar to the results found in a previous study using the same underlying model (Moxnes and Jensen 2009), where the average maximum overshoot of the same goal was 86%, and the median overshoot 81%. This is a clear indication of a misperception of the dynamics of alcohol uptake in the body.

After having explored the funnel and glass simulator, the participants were again challenged to reach the 0.8 g/l goal using the funnel and glass simulator with the funnel covered. Hence while the interfaces differed, the two challenges were similar in that no information was available about alcohol in the stomach. The average maximum overshoot was 45% higher than the announced goal and the median 14% higher (N=58). The within sample reduction in maximum overshoot from the first to the second challenge is significantly greater than zero (p=0.01). The percentage of participants with a maximum overshoot exceeding 100% was reduced from 25 to 10%.

4.2. Questionnaire results on learning

In Q1 the subjects were asked to report causes of becoming more intoxicated than intended based on own experiences (q4). In Q3 they were asked to report causes for juveniles in general, ($q_3$4). Table 3 shows the percentage of answers grouped in internal[2] and external[3] causes. The internal causes typically point to the drinker's lack of experience and knowledge, usually without being specific. Q1 was answered immediately after receiving information about the uptake of alcohol in treatments T1 and T2. Q3 was answered nearly two months after information was received. The sample suggests that there is less focus on internal causes in T3 than in the two other treatments. An independent samples t-test shows that the only marginally significant difference is between T2 and T3 in Q3, p=0.07. There is no significant change in the percentage of internal explanations for any of the treatments.

In Q3, subjects in T1 and T2 were asked to explain what the information treatments were about ($q_3$7). Suggestions were categorized as being about dynamics[4], advice[5], and other mechanisms[6].

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2 Internal causes include the following categories: Drinking too fast, overestimate how much one can drink, alcohol impairs judgment, delayed uptake in body, lack of experience, trying to maintain level of intoxication, and searching for perfect intoxication.

3 External causes include the following categories: Availability of alcohol, little food intake, mixing of types of alcohol, mood at parties, good taste of drinks, varying tolerance for alcohol, peer pressure, desire to get very intoxicated, and little sleep.

4 Dynamics include: BAC continues to increase after ending drinking, how fast BAC changes, BAC goes higher than expected, one does not get sober quickly, and that there is a building up of stocks.

Table 4 shows the results. Most important, when prompted by this question, participants did recall insights about both dynamics and advice. Independent samples t-tests show that the difference between treatments with respect to recall of dynamics is marginally significant, $p=0.09$, while the difference with respect to advice is highly significant, $p<0.001$. As one may have expected, simulator treatments tend to give more insights into dynamics, while the one page with written information tends to strengthen the recall of the advice given.

Table 3: Number of reported causes of getting more intoxicated than intended and percentage of internal explanations.

	Q1 – own experiences		Q3 – in general	
	N	Internal %	N	Internal %
T1	18	43	24	62
T2	15	64	96	62
T3	13	35	61	47

A more concrete test of the subjects' understanding of the dynamics of alcohol is represented by the question in Q3 where they were asked to predict the BAC after one hour of drinking and after a following ½ hour without drinking ($q_3 6$). To judge the results, answers were compared to expected BAC levels given weight and gender. The general tendency was to overestimate the BAC after one hour, by about 60 per cent, and to underestimate the increase after drinking

5 Advice include: One should plan drinking, one should be conscious, one should mind ending drinking, one should avoid accidents, one should have a drinking strategy, one should drink slowly, and one should take breaks.

6 Other mechanisms include: The speed of metabolism, how alcohol influences the body, that the system is difficult, and that BAC vary with weight.

stopped. This tendency is consistent with mental models where stomach delays are not properly accounted for.

Table 4: Responses to questions about what the information was about, in percent of all suggestions. N is the number of suggestions.

	Subjects	N	Dynamics	Advice	Other
T1	19	23	43	26	30
T2	51	64	34	44	22

Table 5: Percentage of correct answers when predicting changes in BAC from 10pm to 10:30pm. N is the number of answers.

	N	Direction
T1	17	82
T2	58	59
T3	42	52

The focus here is on the predicted change in BAC over the ½ hour with no drinking. Table 5 shows that subjects who received simulator training in T1 gave better predictions of the direction of change than those with other treatments, with p-values of respectively 0.08 and 0.03 when compared to T2 and T3 (Mann-Whitney). In both T2 and T3, more than 40 percent expect the BAC level to decrease.

When subjects were asked if they though about the information they had received when drinking ($q_3$8), 52% answered yes in T1 and 35% in T2. The difference was not statistically significant, p=0.15 (Mann-Whitney). When asked if they had discussed the information with others ($q_3$9), 32% answered yes in both T1 and T2.

4.3. Effects on drinking

A more ambitious task than to improve knowledge is to influence drinking behavior in the direction of increased net benefits. Table 6 gives an overview of number of subjects (N), drinking episodes (DE), percent overshooting episodes (OE), and percent regrettable episodes (RE) for the three time periods covered by the three questionnaires. The table shows that some of the respondents in Q1 did not show up for Q2 and Q3, this was particularly the case for T1 in Q3. The average number of drinking episodes per three weeks did not differ in Q1 (all p>0.12). In Q2, the T1 group had a significantly higher number of drinking episodes than T2 and T3 (both p<0.001), most likely explained by the fact that while T2 and T3 answered Q2 before Easter holidays, T1 answered Q2 after. In Q3, T2 had significantly fewer drinking episodes than T1 and T3 (both p<0.01) and T1 had more drinking episodes than T3 (p=0.05). The much higher number of drinking episodes in Q3 than in Q1 an Q2 is due to a long period of celebration at the end of high school ("russetid").

The percentage of drinking episodes where students overshoot their intended level of intoxication (OE) is on average for all treatments 29 per cent in the three-week period before the study started (Q1). This average drops to 17 per cent in Q2 and to 18 per cent in Q3. This tendency is somewhat similar to what Moxnes and Jensen (2009) found for a similar sample, where self reported incidents of overshoots dropped from 28 to 16 percent over a longer time period. Over all treatments, the percentages of subjects that experienced at least one overshoot, were respectively 49, 39 and 62 in Q1, Q2, and Q3. The percentage of students that reported at least one episode of overshoot over all three periods was 66.

Table 6: In preceding three weeks: average number of drinking episodes (DE), and if drinking: percent overshooting episodes (OE) and percent regrettable episodes (RE).

	Q1				Q2				Q3			
	N	DE	OE	RE	N	DE	OE	RE	N	DE	OE	RE
T1	61	2.41	28	8	46	3.43	21	5	23	10.5	19	2
T2	75	1.87	21	4	62	1.90	14	2	65	6.03	19	2
T3	61	2.08	38	11	45	1.67	17	7	49	8.12	18	4

Except for in Q1, where OE is higher for T3 than for T2 (p=0.02), there are no significant differences between the three treatments. In Q3 the fractions are practically identical. This may reflect that in the last period the students participated in similar type parties and to some extent the same parties. In earlier periods, parties may have been more different. Since OE is highest in the control treatment T3 in Q1, it is obvious that the data indicate no effect of information treatments on drinking behavior in terms of overshooting episodes.

There is no effect of treatments on the tendency to repeat overshoot episodes. Over all three treatments, 78 per cent of those who experienced one or more overshoots in Q1 or Q2 experienced one or more overshoots in subsequent Q2 or Q3 (subjects that report drinking in only one questionnaire were excluded). There is clearly limited learning from experience. Among those that did report zero drinking in Q1 or Q2, on average 20 per cent of the drinking episodes in Q3 led to overshoots and 59 per cent of the persons in this group did report at least one incidence of overshoot. Hence, those that reported modest drinking early on, seems to follow the same pattern as more heavy drinkers in the celebration period (Q3).

The average number of painful and regrettable episodes (RE) over all treatments decreases from 8, to 5, and to 2 per cent of all drinking episodes over the study period. In none of the periods are there any significant differences between treatments. The percentages of students that experience at least one regrettable episode are respectively 15, 13, and 21 for Q1, Q2, and Q3. The percentage of students that reported at least one regrettable episode over all three periods was 28. Differences between treatments are not significant.

Table 7 shows how the number of drinks per episode per liter of body waters varies over treatments and questionnaires. The general trend is an increase in drinking over time, with a maximum during the celebration period. An ANOVA analysis shows that there are significant differences between treatments - or schools ($p<0.001$), where T2 is different from T1 and T3. There are also significant differences between questionnaires - or points in time ($p=0.001$), where both Q1 and Q2 are lower than Q3. No interaction effect is significant.

Table 7: Average drinks per drinking episode per liter of body waters.

	Q1	Q2	Q3
T1	0.19	0.21	0.22
T2	0.15	0.15	0.18
T3	0.18	0.19	0.24

Table 8 shows the results of linear regressions where drinks per liter of body waters (DPBW) are explained by DPBW at an earlier point in time (Q2 versus Q1, Q3 versus Q2, and Q3 versus

Q1), by Treatment (T1 versus T3 and T2 versus T3), and by a constant. In the regression model, treatments are respectively represented by the value 1.0 for T1 and 0.0 for T3 or by the value 1.0 for T2 and 0.0 for T3.

In all six regressions DPBW is highly dependent on the DPBW at an earlier time. Both simulator training (T1) and written information (T2) show negative sample effects on drinking. In the first period from Q1 to Q2 treatment effects are small and statistically insignificant. In the second period from Q2 to Q3 and over the entire period from Q1 to Q3, sample effects of treatments are larger. While the effect of written information is highly significant, the effect of simulator training is not significant. These regressions imply that one cannot rule out a certain effect of training on drinks per liter of body waters. However, confounding effects of underlying differences between the schools could also explain the apparent treatment effects.

Table 8: Results of regression where the

		Q1 versus Q2		Q2 versus Q3		Q1 versus Q3	
		coeff.	p-value	coeff.	p-value	coeff.	p-value
T1 vs. T3	DPBW	0.82	0.000	0.86	0.000	0.71	0.000
	Treatment	0.00	0.996	-0.031	0.11	-0.025	0.21
T2 vs. T3	DPBW	0.90	0.000	0.93	0.000	0.84	0.000
	Treatment	-0.013	0.19	-0.043	0.000	-0.047	0.000

To illustrate the size of the effect of T2, when going from Q1 to Q3, drinking drops by 0.047 drinks per liter. Without the treatment effect, drinking would have been 0.227 drinks per liter.

The reduction is 21 percent. The corresponding effect of T1, however insignificant, is a reduction of 10 per cent.

Similar regressions for overshooting episodes (OE) and regrettable episodes (RE) did not produce any significant treatment effects. There were certain tendencies for such episodes in Q3 to be explained by similar episodes in Q1 or Q2, indicating limited learning from "teachable moments".

5. CONCLUSIONS

The first challenge in the simulator training produced similar results to an earlier study (Moxnes and Jensen 2009). Both studies used the same underlying model, however interfaces differed. Hence, it seems that using colors to denote the BAC rather than exact numbers and removing monetary incentives do not lead to very different results (assuming the two design differences did not cancel each other). While training with the funnel and glass simulator leads to considerable reductions in overshoots in the simulator, about 10% still overshoot the goal by more than 100%. One may also question how deep the apparent learning is; a simple trial-and-error procedure would also lead to less overshoots.

When listing causes of overshoots, about fifty per cent of the suggestions point to specific external causes. Internal causes are less specific, mostly pointing to lack of experience and knowledge. The information treatments (T1 and T2) seem to lead to a slightly higher reported frequency of internal causes. When prompted with a question that required the students to recall the information given, they did mention both dynamics and advice. The simulator training did have a positive effect on students' ability to predict BAC levels after drinking. Without simulator training there is a tendency to think that the BAC increases quickly and then stagnates or even declines within half an hour. According to the questionnaires, received information had been given some thought when drinking and about one third had discussed the information treatments with others. This signals a potential for diffusion of information with this type of training.

Among all participants, 66 percent experienced at least one episode where they became more intoxicated than intended. Correspondingly, 28 percent reported at least one painful and regrettable episode. Self-reported episodes of becoming more intoxicated than intended and experiencing regrettable episodes show no differences between treatments or over time. No other explanatory variables seem to explain these episodes. Over the entire period, the number of drinks per liter of body waters decreases by 21 per cent for those who receive the printed information treatment (T2). However, due to the research design, this apparent treatment effect could also result from underlying differences between schools.

The delay that is caused by the accumulation of alcohol in the stomach (the funnel effect) is important no matter what other internal or external effects are in play. The delay matters whether one has eaten or not, whether the mood at a party is good or bad, independent of type of alcohol etc. It matters for infrequent drinkers, as well as for heavy drinkers. The present study supports the previous finding (Moxnes and Jensen 2009) that young people do not understand the dynamics of alcohol uptake in the body and that learning from experience is slowed down by lack of appropriate mental models. Hence, there is a need for better understanding.

While simulator training led to better forecasts of how intoxication develops over time, the interventions were not successful in terms of reducing overshooting and regrettable episodes.

Since many students reported that mood at parties influence drinking, it could be that the mood in the celebration period with its strong norm (and peer pressure) in favor of binge drinking, came to dominate the training.

Another possible weakness of the research design was the short time students spent on the information treatments. The average and median time spent on the entire simulator task (T1) was just below 10 minutes. The average time spent on the written information (T2) was not measured, however certainly well below 10 minutes. In light of the complexity of dynamics and the weak background most students have regarding dynamics, the weak effects on learning and behavior may not be surprising. Further research should test the effect of simulator training when this training is embedded in ordinary teaching, allowing for more time and repetition.

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