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Calculating alcohol risk in a visualization tool for promoting healthy behavior

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ABSTRACT

Objective: To investigate effective methods for communicating the *personalized* risks of alcohol consumption, particularly to young people.
Methods: An interactive computerized blood alcohol content calculator was implemented in Flash based on literature findings for effectively communicating risk. Young people were consulted on attitudes to the animation features and visualization techniques used to display personalized risk based on disclosed alcohol consumption.
Results: Preliminary findings reveal the calculator is relatively enjoyable to use for its genre. However, the primary aims of the visualization tool to effectively communicate personalized risk were undermined for some users by technical language. Transparency of risk calculations might further enhance the tool for others. Worryingly, user feedback revealed a tension between accurate presentation of risk and its consequent lack of sensationalism in terms of personal risk to the individual.
Conclusion: Initial findings suggest the tool may provide a relatively engaging vehicle for exploring the link between action choices and risk outcomes. Suggestions for enhancing risk communication include using intelligent techniques for selecting data presentation formats and for demonstrating the effects of sustained risky behavior.
Practice implications: Effective communication of risk contributes only partially to effecting behavior change; the role of the tool in influencing contributing attitudinal factors is also discussed.

1. Introduction

There is no shortage of literature on the risks of drinking, and it is beyond doubt that, as an individual's alcohol intake increases, so does their likelihood of fatality [1–3]. There is a wealth of evidence, including a meta-analysis of studies of alcohol-drinking, showing a strong dose–risk relation between alcohol and cancers [4], and between alcohol and trips to the emergency department [5,6]; while the World Health Organization (WHO) reports that typically 20% of injuries involve alcohol, and these mostly involve patients were under the age of 35 [7].

Recent research [8–10] suggests that personal salience plays a special role in alcohol-related risks. While risks are acknowledged for members of their peer group, people tend to disassociate this from the risks to themselves. Young people who drink more tend to be optimistic about personal risk, to live more 'for the moment', and perceive themselves as having high self-control.

A study of college students' perceptions of problems due to alcohol showed a strong positive relationship between subjects' 'unrealistic optimism' and the number of alcohol-related negative events (hangovers, missed classes, and arguments with friends) that they experienced six months, one year and 18 months later [11]. These are confirmed in a study of undergraduates' perspectives about time and in relation to health behaviors, including alcohol consumption: students who had a hedonistic 'enjoy life now' perspective reported greater alcohol use than those who gave more consideration to the future [12].

This paper describes preliminary work on the development of a visualization tool for calculating and communicating to young people the long- and short-term risks of alcohol consumption (see Fig. 1). Its purpose is to inform the relation between their drinking behavior and national guidelines, and the health risks that they personally face. It forms part of a study concerned with curbing the damaging health consequences of binge drinking in young adults and teenagers. Key elements include:

- informing individuals about the consequences of their behavior in a manner that supports motivation and perceived self-efficacy;
- identifying methods to communicate risk that are effective for the target audience of teenagers and young adults; and

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Fig. 1. 'Jim the bartender' graphical interface for drinks selection in the Alcohol Risk Calculator [22].

- identifying features of potential visualization tools that will engage the target audience, lead them to discover the impact of their drinking habits on their own health and to explore the potential consequences of changes in their drinking pattern.

Binge drinking can be hard for doctors, parents and teachers to diagnose as they are often not around during the event. We hypothesize that teenagers will be more willing to expose their binge drinking behavior to a computer program and that they will be more truthful in their responses if they are confiding to a computer program in private rather than communicating with an authority figure, with or without the presence of their peers. Using the information provided by a user, as well as known data on risks, a system can calculate risks faced by an individual.

The idea of a risk calculator is not new. The Harvard Cancer Risk Index, first printed in 1997, has been developed into 'Your Disease Risk', a calculator that works out the risk of developing a range of cancers [13]. Similar calculators link more directly to alcohol consumption, calculating aspects of the user's drinking habits such as blood alcohol concentration (BAC), the number of calories consumed, or how much money is spent [14–17]. However, none of these inform the user of the risk of personal injury based on the amount they drink. Many of the existing alcohol calculators are also unexciting for young people. We believe that a calculator is more likely to engage young people, and thus have a better chance of influencing their behavior, if it can be made to be entertaining and interesting.

1.1. Influencing health-related behavior

There is general agreement that human behavior is goal-directed; actions are controlled by intentions. The most influential theoretical accounts of this relationship are provided by Ajzen and his colleagues. The theory of reasoned action (TRA) proposes that actions can be traced through causal links from beliefs, through attitudes and intentions to the resulting behavior [18].

The TRA assumes that human beings largely behave in a sensible manner; they consider available information and implications; and individuals' intentions determine actions. The determinants of intentions themselves are twofold:

Personal: the individual's evaluation of, and attitude toward, the behavior in question. These are said to arise from 'behavioral beliefs'.

Social: the individual's perception of the social pressures put upon them, particularly their views on whether trusted others would approve or disapprove of their behavior. Ajzen [18,19] terms this the 'subjective norm' giving rise to 'normative beliefs'.

Their relative weights can vary by person and by behavior. According to the theory, the beliefs of a given individual represent the information that he or she has about the world. Therefore, by changing information, it is possible to change behavior.

Irvine and colleagues [20] used TRA and self-efficacy theory to inform the design of an interactive multimedia system that included video modeling vignettes and testimonials. Their system was designed to encourage users to overcome barriers to healthy eating. The TRA informed the system's authors' use of video testimonials that "offered encouragement to try recommended behaviors" [20, p. 293].

The TRA theoretical account was later extended to include consideration of the individual's behavioral control in realizing their intentions, in the theory of planned behavior (TPB) [19], giving rise to a third determinant of intention:

Behavioral: the individual's perceived self-efficacy in realizing an intention. The TPB addresses the individual's control over external factors that facilitate or impede their intentions. Crucially, behavioral control is tempered by the individual's *beliefs* about their ability to perform the given behavior; they may be able but believe they are not. Ajzen [19] terms this 'perceived behavioral control' giving rise to 'control beliefs'.

1.2. Support for understanding statistics

'Collective statistical illiteracy', is a phenomenon with serious consequences for health, relevant to patients and health professionals. In an influential study, Gigerenzer and his colleagues [21] claim that at the root of the problem is the use of non-transparent statistics. According to them, statistics should be presented in terms of *natural frequencies* instead of the commonly used *conditional probabilities* (see Table 1), since natural frequencies facilitate computation.

2. Methods

2.1. Calculating risk

We summarize briefly here the accepted methods for calculating the risk of acute and chronic outcomes of alcohol consumption. These methods are employed directly in our tool.

For acute risk we adapted a formula developed by Rehm et al. [1] for the probability of death (PoD), per 1000 people (see Eq. (1)), based on a baseline level of risk (*BR*), a relative level of risk (*RR*) based upon how much the person drinks, a risk period (*RP*), also based on alcohol consumed, and the number of drinking occasions per year (*N*):

$$Pod = 1 - \left(\frac{1 - (BR \times RR)}{RP}\right)N \qquad (1)$$

The baseline risk (*BR*) is the number of people who would suffer a specific injury without including the alcohol-attributable fraction (*AAF*) of injuries. The relative risk (*RR*) increases based on the amount of alcohol drunk and was similarly adapted by Bissett [22] from the original calculations in Rehm et al. [1]. The risk period (RP) is based on the time it takes for a person's alcohol levels to return to 0, based on the amount drunk and their age, height and weight.

Table 1
Conditional probabilities vs. natural frequencies.

Conditional probabilities	Natural frequencies
The probability that a woman has breast cancer is 1% (prevalence)	10 out of every 1000 women have breast cancer (prevalence)
If a woman has breast cancer, the probability that she tests positive is 90% (sensitivity)	Of these 10 women with breast cancer, 9 test positive (sensitivity)
If a woman does not have breast cancer, the probability that she nevertheless tests positive is 9% (false positive rate)	Of the 990 women without cancer, 89 nevertheless test positive (false positive rate)

Source: Adapted from Gigerenzer et al. [21, p. 56].

A similar formula is used to calculate the risk of chronic injuries (see Eq. (2)), also adapted from Rehm et al. [1]:

$$PoD = (TR \times AAF) \times YAB \tag{2}$$

The total risk (TR) represents the number of people who would die of an illness or disease in 1 year regardless of their alcohol consumption. The total risk is multiplied by the AAF, which is the proportion of these deaths that would be avoided in the absence of alcohol. The result of this gives a one-year risk, per 1000 people, of dying from a chronic injury. To create a lifetime risk, this is multiplied by the number of years in the age bracket (YAB) i.e. 31–40 is 10 years.

Risks of hospital admission for both acute and chronic injury are created from the same formulae, with data on the number of deaths substituted for the number of hospital admissions.

2.2. Risk presentation

Our approach adopts the finding that risk information relevant to individuals is of greater value than average population data [23]. This approach is supported by positive and enduring changes in self-reported healthier eating following the use of 'tailored' interactive video multimedia reported by Irvine and colleagues [20]. For this reason the system requests more data from the user than many similar calculators, so as to create results with a relatively high level of personalization.

Risks can be presented numerically, graphically, textually or in combination, and it is generally accepted that the use of combined media leads to better understanding [24,25]. In the design of the calculator's results we took inspiration from the results of reviews by Lipkus and Holland [26] and Edwards et al. [27] which suggest that bar charts are generally well understood by patients, and often preferred over other formats (e.g., pie-charts, pictograms, survival curves).

However, despite extensive research on the effect of various numerical presentations (relative risk, absolute risk, etc.) on risk perception, relatively little is known about the effect of the various types of visual displays independently, or in combination with numerical or textual translations (see Lipkus and Holland [26] for a review). Specifically, few studies address teenagers. We aim to explore these issues empirically with teenagers using an Alcohol Risk Calculator, incorporating in the calculator the outcomes of new studies as they appear.

2.3. The Alcohol Risk Calculator

The Alcohol Risk Calculator (implemented in Adobe Flash CS4) is designed to be highly accessible to a wide variety of users and adheres to Nielsen and Mack's [28] design heuristics. Its current design is inspired by the findings in the literature reported above, and by a survey of 25 existing web-based calculators (see Bissett [22]).

In order to make it effective, we chose in our initial prototype to:

- personalize the communication of risk;
- use a combination of all three media: text, numerical information, and simple graphics;
- focus on absolute risk (following Gigerenzer et al. [21]); and
- use bar charts for data presentation.

An entertaining and informal scenario was created whereby users would visit a virtual, interactive bar, and engage with a barman, 'Jim', who would ask them a series of questions. In dialog between the user and Jim, text is minimized in favor of interactive graphical elements, with many questions presented pictorially; although these tend to take longer to complete than traditional response field questionnaire formats, it is felt that they are more engaging.

2.3.1. The user–system dialog

The dialog between the system and the user is mixed-initiative. The system's questions are based on an existing tool for assessing binge drinking [29]. These assess height, weight, age, drinking pattern, drinking volume, and time of drinking over five screen displays.

2.3.2. System calculations

The system's calculations are based on two sets of information: (1) that provided by the user in answer to the questions posed by Jim the barman and (2) data such as alcohol-attributable fractions for England, as well as mortality and hospital admission data from 2005 in England, taken from a study by Jones et al. [30]. AAFs describe the percentage of incidents that would not occur in the absence of alcohol e.g., alcohol poisoning. The AAF is 1 for entirely attributable chronic conditions that would never occur in a world without alcohol. For all other chronic and acute conditions, the fraction is expressed as a decimal point number between 0 and 1.

2.3.3. System screen displays

Figs. 1 and 2 show screenshots of different forms of user interaction in answering questions. In Fig. 1 the user is 'chatting' to Jim the barman, responding to a question about their typical drinking behavior by selecting drink icons and moving them onto Jim's tray. In Fig. 2, the user answers personal demographic information.

Fig. 2. Screen requesting demographic data for use by risk calculation formulae.

Fig. 3. Display of BAC and units consumed in the Alcohol Risk Calculator.

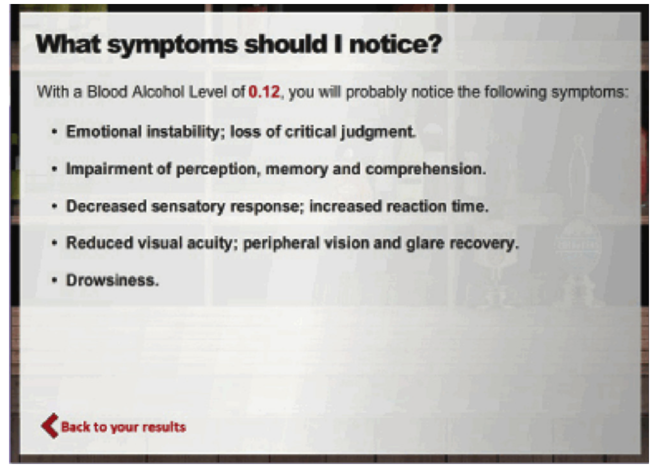

Fig. 4. Results page showing range of symptoms induced by alcohol consumed.

Figs. 3–5 show examples of the system's response to the user. In Fig. 3 the system tells the user his blood alcohol concentration, reminds him of the drinks consumed and the time over which they were consumed, relating this BAC to the national guidelines for alcohol consumption. The user is given the option to get more information about concomitant risks or likely symptoms.

Fig. 4 shows the system's response to the user clicking on the "What symptoms should I notice?" button in Fig. 3. The screen display shows some of the symptoms typically experienced by similarly inebriated individuals.

Fig. 5 shows the system's response to the user clicking on the "What risks do I face?" button in Fig. 3. The user is presented with a mixture of graphical and text formats, with the key information highlighted, and combined use of natural frequencies and bar chart.

3. Results

We have conducted an early qualitative evaluation of the calculator with six young adults (university graduates, aged 21–26) to explore issues related to its ease of understanding, enjoyability, and engagement.

Each participant used the calculator on a laboratory laptop and then completed a paper-based questionnaire composed of the following four questions:

Did you understand how to use the program? All participants said that they were able to understand how to use the program successfully.

Did you enjoy using the program? Four of the participants said they enjoyed using the calculator, one remarking that they liked 'Jim' the barman, and another that "It's quite fun!". Two participants were less enthusiastic although still positive, one commenting "In so far as one can enjoy a program like this, it's different to many of this sort of calculator" implying the Alcohol Risk Calculator was relatively enjoyable for its genre.

Did you feel engaged with the program? The same two participants said they did not engage with the calculator. However, the other four indicated that they did find it engaging, one alluding to 'Jim the bartender' who provided an informal front to the system and made it 'seem friendly'. One participant suggested that engagement might be improved by incorporating sound.

Did you understand the results of the program? Everyone said they understood the results, although one person stated they did not really understand what was meant by blood alcohol concentration.

3.1. Summary of results

This small study of users' reactions to the Alcohol Risk Calculator has provided valuable insights for the next iteration of its design, especially through the criticisms received. For example:

- as mentioned, one participant suggested that engagement would be enhanced with the inclusion of sound. An obvious extension of this idea would be to make use of AI-based animated conversational agents;
- another participant indicated a wish to know how the results were calculated, an issue of transparency. This, together with the earlier mentioned comment on blood alcohol concentration, could be addressed by incorporating hyperlinks to explanatory information for key concepts; and
- two participants indicated they found the risks displayed surprisingly low. We discuss this in more detail below.

4. Discussion and conclusion

4.1. Discussion

Encouraging take up of the tool is paramount if information regarding the risks of binge drinking is to reach our target

Fig. 5. Results graph (bar chart) showing five top risks to life.

audience: young people. Our pilot user evaluation study suggests the Alcohol Risk Calculator contains the necessary elements of novelty and enjoyability to achieve this, potentially enhanced by the possible future extensions described below. By engaging young people in its use, the Alcohol Risk Calculator thus offers a means to open up communication channels on the dangers of binge drinking, necessary if the behavior of those young people is to be influenced.

The findings of Sjoberg [10], Dillard et al. [11] and Henson et al. [12] are particularly revealing in identifying the relationship between attitude and both alcohol use in particular and risk-taking in general. They suggest that potential targets for attitude, knowledge and (ultimately) behavioral change include changing optimism to realism, changing hedonistic present-time perspectives to future-time perspectives, and addressing high levels of risk denial.

Through the development of a visualization tool that will engage the target audience, and thus lead them to discover the impact of their drinking habits on their own health and to explore the potential benefits (or otherwise) of changes in their drinking pattern, the Alcohol Risk Calculator allows users to relate personal alcohol consumption to its resulting risks; a first step in overcoming the delusion that the risks of binge drinking only hold for others, not themselves [8,10]. The Alcohol Risk Calculator also allows users to experiment with varying the amounts of alcohol consumed to reveal the consequent increase or decrease in risk. This feature lends itself to enhancing the users' perception of behavioral control that appears crucial in taking this step [10]. According to Kreuter et al. [31] the more we understand about the relationship between these factors, the more accurately our interventions can be designed to influence behavior in the desired direction; if ignored an intervention may fail because it does not address the attitudes and norms that influence intent and motivate behavior.

Misperceptions and risk denial might be overcome by personalized normative feedback interventions [32]. For example, Chen [33] found that using an Interactive Alcohol Risk Calculator (IARC) led to changes in attitudes toward alcohol. The IARC assessed users' reaction to threat based on Witte's Extended Parallel Process Model (EPPM) [34,35] and used this to adapt the presentation of personalized risk outcomes. The EPPM is a motivational model that relates threats or fear appeals in health messages to behavior change. Witte [34] argues that people process the threat conveyed in a health message according to both cognitive and emotional factors: cognitively, people may change their attitudes, intentions, or behaviors to prevent the threat from occurring, leading to message acceptance; but people may also respond emotionally, denying the threat, leading to message rejection. Based on the Risk Behavior Diagnosis Scale [35], users who were assessed as able responders to danger were presented with an assessment of their risk outcomes couched in terms that emphasized the dangers of continuing or increasing their alcohol consumption; whereas users who were assessed as more likely to respond fearfully to fear appeals were presented with their calculated risk outcomes couched in terms that emphasized the benefits of reducing their personal level of alcohol consumption [33]. Comparison of pre- and post test scores using the B-CEOA [36] involving 16 participants revealed significant changes in attitude to alcohol following relatively brief exposure (3 days) to using the IARC [33]. These findings suggest that devices such as the Alcohol Risk Calculator offer a means of affecting attitudes toward alcohol.

4.1.1. Limitations and future directions

The work presented here is based on a small scale preliminary study with its inherent limitations. A proper evaluation of the tool would clearly require a study involving a larger number of participants and would include participants with different levels of literacy and numeracy skills. It would also be helpful to compare the calculator with other similar tools and to test it with validated usability instruments.

There is also further consideration required regarding the methods used to present risk, to best support our underlying purpose of effecting behavior change. Building on the approach advocated by Gigerenzer and colleagues [21], a valuable extension to the calculator might be to take some simple steps to educate the user in understanding the risk information presented. Evidence suggests educational attainment is strongly related to graphical literacy with the most commonly well-understood format being the bar chart, as our evaluation study reflects [22]. However, other representational formats may better convey the risk information presented. Cox's previous work developing an AI-based graphical tutor indicates that proffering a selection of graphical formats, whilst recommending that which best portrays the data, results in greater accuracy in interpreting that data [37,38]. Allowing the user to switch between several representational formats may not only help users to better understand the risk presented [25] but may also serve to improve their graphical literacy [37,38].

Another aspect of our risk presentation that could be further assessed is the decision to use absolute risk (e.g., 1 in 1000) as proposed by Gigerenzer et al. [21], instead of relative risk (e.g., 10% increase). We see the issue in the reaction of some users (including some of the authors) to the information given in Fig. 5: the risks appear negligible. The problem is that absolute risks are typically small numbers and their corresponding numbers for relative changes will be large. While we know that information using relative risk can be more persuasive than absolute risk [27], it also runs the risk of being unduly misleading. An obvious solution would be to provide both types of information; providing a comparison with everyday risks may also be very helpful. Connected with this is the work done by Chen [33] on the IARC, where giving users risk outcomes to suit their individual differences might further encourage exploration with the tool, offering opportunities for consequent connections between perceived behavioral control and behavior change.

The likelihood of users accepting the calculator's health messages may also be encouraged by AI-based solutions such as applying face- and body-morphing software for before-and-after pictures (this is what you will look like in 5, 10, 20 years if you carry on drinking like this, compared to if you do not). Another potentially helpful route could be to increase the level of interaction between the user and the system using an animated conversational agent. Work on conversational interface agents [39] indicates the plausibility of this approach using current technologies to capture speech, gaze, posture and gesture. By giving 'Jim' more autonomy as a conversational agent, this could encourage the users to communicate more honestly with the tool and to use the calculator more often.

A relatively simple way of further enhancing the tool could be for the results section to link to websites such as the NHS [40], anti-drinking campaign websites such as that for 'drinkaware' [41] or news articles with information on the listed injuries and diseases [42]. This could make risks seem both more tangible and understandable to the user and therefore significantly increase awareness, as well as extending the system's dialog capacity.

Further, by encouraging repeated interaction with the Alcohol Risk Calculator over time, user inputs could be analyzed to gain insight into the efficacy of the tool in affecting behavior, such as reduced alcohol consumption. This analysis could additionally provide material to allow the system to adapt its behavior to the user in order that the most effective risk presentation format is selected for each individual. Work by Nguyen and Sobecki [43] demonstrates how the techniques of recommender system profiling can be applied to categorizing users, using a mixture of direct input data and observations of user–system interaction, as a basis for adapting the information presented.

4.2. Conclusion

Our aim in developing an Alcohol Risk Calculator is to provide a test-bed for exploring the efficacy of AI-inspired solutions for communicating the health risks associated with binge drinking to a target population of those most likely to engage in this type of behavior – teenagers. Not surprisingly, our initial prototype has raised more questions than it has provided solutions. Our work will need to be evaluated on at least two fronts. On the one hand, we will need to test the efficacy of the tool as a mechanism for successfully communicating the risks to a given teenager arising from his or her binge drinking activity. On the other hand, there is the issue of efficacy of the tool as a health intervention for reducing binge drinking among teenagers. Each of these will pose challenges of their own.

4.3. Practice implications

Communicating the risks of excessive alcohol consumption through the use of an engaging, interactive visualization tool may contribute to behavior change by enabling users to explore the relationship between various patterns of alcohol consumption and their personalized consequences for risk outcomes, in a way that makes the personal risk to the individual clear and avoids the delusion that such risks apply only to others. Exploration with the tool may also kindle users' self-efficacy in influencing their personal health outcomes through visualizing the benefits accruing from incremental reductions in alcohol consumption; attitudinal factors such as this could play a pivotal role in influencing the individual decision to reduce the amount of alcohol consumed. Conclusive findings on these potential benefits await further work.

Conflict of interest statement

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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References

[1] Rehm J, Room R, Taylor B. Method for moderation: measuring lifetime risk of alcohol-attributable mortality as a basis for drinking guidelines. Int J Meth Psychiatr Res 2008;17:141–51.
[2] Single E, Robson L, Rehm J, Xi X. Morbidity, mortality attributable to alcohol, tobacco, and illicit drug use in Canada. Am J Public Health 1999;89:385–90.
[3] WHO. Quantifying selected major risks to health: reducing risks, promoting healthy life. In: The World Health Report. 2002;p. 47–97.
[4] Bagnardi V, Blangiardo M, La Vecchia C, Corrao G. A meta-analysis of alcohol drinking and cancer risk. Brit J Cancer 2001;85:1700–5.
[5] Borges G, Cherpitel C, Orozco R, Bond J, Ye Y, Macdonald S, et al. Multicenter study of acute alcohol use and nonfatal injuries: data from the WHO collaborative study on alcohol and injuries. Bull World Health Organ 2006;84:453–60.
[6] Corrao G, Bagnardi V, Zambon A, Arico S. Exploring the dose–response relationship between alcohol consumption and the risk of several alcohol-related conditions: a meta-analysis. Addiction 1999;94:1551–73.
[7] WHO. Alcohol and injury in emergency departments, collaborative study on alcohol. Geneva, Switzerland: World Health Organization; 2007.
[8] Moreira MT, Smith LA, Foxcroft D. Social norms interventions to reduce alcohol misuse in University or College students (Review). The Cochrane Collaboration. London: Wiley & Sons; 2010.
[9] Sjoberg L. Risk perception of alcohol consumption. Alcohol Clin Exp Res 1998;22:282S.
[10] Sjoberg L. Factors in risk perception. Risk Anal 2000;20:1–11.
[11] Dillard AJ, Midboe AM, Klein WMP. The dark side of optimism: unrealistic optimism about problems with alcohol predicts subsequent negative event experiences. Pers Soc Psychol Bull 2009;35:1540–50.
[12] Henson JM, Carey MP, Carey KB, Maisto SA. Associations among health behaviors and time perspective in young adults: model testing with bootstrapping replication. J Behav Med 2006;29:127–37.
[13] Siteman Cancer Center; 2013, www.yourdiseaserisk.wustl.edu/ [accessed 10.03.10].
[14] Drinkaware Drink Diary; 2013, www.drinkaware.co.uk/tips-and-tools/drink-diary/ [accessed 10.03.10].
[15] MyDr Alcohol Calculator; 2013, http://www.mydr.com.au/tools/alcohol-calculator [accessed 10.10.10].
[16] Alcohol Calorie Calculator; 2013, http://www.talktalk.co.uk/lifestyle/calculators/alcohol.html [accessed 10.10.10].
[17] Drink-o-Meter; 2013, http://www.iondesign.net/drinkometer/ [accessed 10.10.10].
[18] Ajzen I, Fishbein M. Understanding attitudes and predicting social behavior. Englewood Cliffs, NJ: Prentice-Hall; 1980.
[19] Ajzen I. From intentions to actions: a theory of planned behavior. In: Kuhl J, Beckmann J, editors. Action control: from cognition to behavior. Heidelberg: Springer; 1985. p. 11–39.
[20] Irvine AB, Ary DV, Grove DA, Gilfillan-Morton L. The effectiveness of an interactive multimedia program to influence eating habits. Health Educ Res 2004;19:290–305.
[21] Gigerenzer G, Gaissmaier W, Kurz-Milcke E, Schwartz L, Woloshin S. Helping doctors patients make sense of health statistics. Psychol Sci Pub Interest 2008;8:53–96.
[22] Bissett S. Alcohol Risk Calculator. Brighton, UK: University of Sussex; 2010 [Unpublished masters dissertation].
[23] Edwards AGK, Elwyn G, Matthews E, Pill R. The effectiveness of one-to-one risk communication interventions in healthcare: a systematic review. Med Decis Making 2000;20:290–7.
[24] Cox R, Brna P. Supporting the use of external representations in problem solving: the need for flexible learning environments. J Artif Intel Educ 1995;6:239–302.
[25] Ainsworth S. The educational value of multiple-representations when learning complex scientific concepts. In: Gilbert JK, Reiner M, Nakhleh M, editors. Visualization: theory and practice in science education. Dordrecht, Netherlands: Springer; 2010.
[26] Lipkus IM, Holland JG. The visual communication of risk. J Natl Cancer Inst Monogr 1999;25:149–63.
[27] Edwards AGK, Elwyn G, Mulley A. Explaining risks: turning numerical data into meaningful pictures. Brit Med J 2002;324:827–30.
[28] Nielsen J, Mack R. Usability inspection methods. Hoboken, New Jersey, USA: John Wiley & Sons Inc.; 1994.
[29] How alcohol affects your health. NHS; 2013, www.nhs.uk/Livewell/over60s/Pages/Longtermeffects.aspx [accessed 10.10.10].
[30] Jones L, Bellis M, Dedman D, Sumnall H, Tocque K. Alcohol-attributable fractions for England. Liverpool: Centre for Public Health, Liverpool John Moores University; 2008.
[31] Kreuter M, Lezin N, Kreuter M, Green L. Community health promotion ideas that work: a field-book for practitioners. Burlington, MA: Jones & Bartlett Inc.; 1998
[32] Walters ST, Neighbors C. Feedback interventions for college alcohol misuse: what, why and for whom? Addict Behav 2005;30:1168–82.
[33] Chen C-Y. Interface design for an Interactive Alcohol Risk Calculator to raise awareness of effects of drinking. Brighton, UK: Department of Informatics, University of Sussex; 2012 [Unpublished masters thesis].
[34] Witte K. Fear control and danger control: an empirical test of the extended parallel process model. Commun Monogr 1994;61:113–4.
[35] Witte K. Predicting risk behaviors: development and validation of a diagnostic scale. J Health Comm Int Perspect 1996;1:317–42.
[36] Ham L, Stewart S, Norton P, Hope D. Psychometric assessment of the comprehensive effects of alcohol questionnaire: comparing a brief version to the original full scale. J Psychopathol Behav Assess 2005;27:141–58.
[37] Grawemeyer B, Cox R. The effects of users' background diagram knowledge and task characteristics upon information display selection. In: Diagrammatic Representation and Inference. Fifth International Conference on the Theory and Application of Diagrams, Herrsching, Germany. Heidelberg/Berlin: Springer-Verlag; 2008. p. 321–34.
[38] Grawemeyer B. Supporting representation selection to improve reasoning: the iterative design of an adaptive system. Brighton, UK: University of Sussex; 2008 [DPhil thesis].

[39] Cassell J. More than just another pretty face: embodied conversational interface agents. Commun ACM 2000;43:70–8.
[40] NHS Livewell Campaign; 2013, http://www.nhs.uk/livewell/alcohol/Pages/Alcoholhome.aspx [accessed 01.13].
[41] Drinkaware Health; 2013, http://www.drinkaware.co.uk/alcohol-and-you/health/how-much-is-too-much [accessed 01.13].
[42] BBC News; 2013, http://www.bbc.co.uk/news/health-18856658 [accessed 01.13].
[43] Nguyen NT, Sobecki J. Determination of user interfaces in adaptive systems using a rough classification-based method. New Generat Comput 2006;24:377–402.