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ORIGINAL PAPER

Sonification and music as support to the communication of alcohol-related health risks to young people

Study design and results

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Abstract Excessive consumption of alcohol has been recognised as a significant risk factor impacting the health of young people. Effective communication of such risk is considered to be one key step to improve behaviour. We evaluated an innovative multimedia intervention that utilised audio (sonification—using sound to display data—and music) and interactivity to support the visual communication of alcohol health risk data. A 3-arm pilot experiment was undertaken. The trial measures included health knowledge, alcohol risk perception and user experience of the intervention. Ninety-six subjects participated in the experiment. At 1 month follow-up, alcohol knowledge and alcohol risk perception improved significantly in the whole sample. However, there was no difference between the intervention groups that experienced (1) visual presentation with interactivity (VI-Exp group) and, (2) visual presentation with audio (sonification and music) and interactivity (VAI-Exp group), when compared to the control group which experienced a (3) visual only presentation (V-Cont group). Participants reported enjoying the presentations and found them educational. The majority of participants indicated that the audio, music and sonification helped to convey the information well, and, although a larger sample size is needed to fully establish the effectiveness of the different interventions, this study provides a useful model for future similar studies.

Keywords Sonification · Music · Interaction · Alcohol · Health risk

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1 Introduction

Misuse of alcohol can significantly affect the health of young people. The introduction of a variety of health educational interventions intended at increasing awareness of harmful effects associated with alcohol consumption [1–3] has improved health risk understanding, although it has failed to convert into a significant reduction in young peoples risky behaviours [4,5]. For example, binge drinking (i.e. drinking large amounts of alcohol in a short time often with the intention to get drunk) is a main public health concern [6] as it has an effect on the development of adult alcohol use disorders [7]. While short-term consequences of alcohol misuse [8,9] are well known, long-term consequences of alcohol abuse, such as liver cirrhosis, cancer, and heart disease, are rarely observable in young people [10]. This leads to long-term consequences rarely being addressed in prevention campaigns as future consequences are not as powerful motivators for young people as short-term ones, despite some researchers suggesting that awareness of long-term impact of alcohol misuse in young people may be associated with decrease in heavy drinking [11]. It is possible that new ways of prevention of alcohol misuse in young people could help tackle this important problem. To this end, communication strategies have to be specifically designed for this segment of the population, for instance by considering the use of mobile devices (e.g smart phones and tablets) which are preferred tools of communication by young people [12,13]. Communication of alcohol-related health risks supported by interactive sonification and music may offer help in this respect as they are novel tools that may appeal to this demographic [14]. Soni-

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fication is a subtype auditory display that uses non-speech audio to convey information [15]. In other words, numerical data relations are converted (or mapped) to perceived relations in an acoustic signal (both musical or non-musical) to enable communication and interpretation [15]. As auditory displays rely on the ability of the human hearing system to distinguish temporal changes and patterns, presentation of numerical data through sound can allow the user to explore and understand a data set and the processes within it in a new and engaging way. It is possible that an examination of a dataset through sonification may highlight specific features, which, if the data are presented visually, might remain less noticeable [16]. Sonifications are currently being used in a wide range of applications from artistic works to data exploration [17]. When a sonification design is interactive, it allows a game-like exploration of data. In the context of communicating alcohol-related health risk behaviours to young people, it could potentially help increase young peoples self-efficacy and control over their drinking habits (while at the same time providing information on how and where to seek help). Presenting information with interactivity and sonification can be combined with music, which many adolescents are interested in [18,19], it relies on technology and can be easily adapted for modern mobile technology, and it does not require advanced numeracy skills, and thus is available to a variety of audiences. Through a 3-arm pilot trial, we tested the hypothesis that a visual presentation augmented by interaction, sonification and music could increase the communicative potential of alcohol-related health and risk messages.

2 Alcohol and young people

Despite geographical, national and local differences in alcohol consumption, including patterns, context of drinking and health consequences, almost 5.9 % of all deaths worldwide, approximately 3.3 million deaths each year (data from 2012), are linked to the consumption of alcoholic beverages [20]. In 2012, consumption of alcohol was found to be responsible for 5.1 % of global burden of disease and injury [20]. Excessive consumption of alcohol has been recognised by the World Health Organization as a significant risk factor impacting the health of young people [20]. A recent English study investigating trends in alcohol consumption in young people has shown that boys and girls are equally likely to have drunk alcohol and the prevalence of consumption of alcohol increases with age from 12 % of 11 years olds to 74 % of 15 years olds [21]. One of the major public health concerns is binge drinking [6,22]. Hazardous drinking patterns are common among university students in many countries [23–25]. Early onset of binge drinking predicts the development of adult alcohol-use disorders [7]. The last decades have seen the introduction of a wide variety of health educational programs with the aim of increasing awareness of harms associated with drinking [3]. One systematic review of 14 systematic reviews found 59 quality programs, however only 6 of them demonstrated some effectiveness [26]. According to Steinberg [27], risk taking in the real world is a product of both logical reasoning and psychological factors, where psychological immaturity often undermines logical decision-making, which may explain the unsatisfactory results of current preventive efforts. Compared to adults, young people minimize their evaluation of the harm associated with periodic involvement in risky health behaviours, which later lead to more serious consequences [28]. It has also been argued that young people do not understand cumulative risks and severity of long-term consequences of such behaviours [29]. One of the serious challenges counteracting any preventive measures in young people is alcohol advertising, particularly in television [30], digital and social media such as emails, text messages and Facebook [31,32]. Studies have shown a positive correlation between alcohol advertisements exposure, alcohol consumption and positive attitudes towards drinking among young people [33,34]. Young people are exposed to alcohol advertising to a greater degree than adults [35] and are particularly vulnerable to the influential messages communicated [36]. The exposure of young people to alcohol advertising varies across different countries as it is sanctioned by local regulations regarding content of alcohol advertisements. A recent study [37] has indicated a significant exposure of adolescents to alcohol advertising particularly in the UK and the Netherlands. The alcohol advertisements are often appealing and memorable to young people (particularly to 15–20 year olds) thanks to the use of humour, music, animation, featuring of celebrities, or animal characters [38,39]. Additionally, Austin and Hust [40] indicated that, in the media, alcohol advertisements exceed the advertisements of non-alcoholic products in the ratio 3 to 1, alcoholic beverages commercials seldom contain risky or dangerous situations directly related to alcohol consumption, and, what is particularly concerning, that some of the commercials specifically target young people. With respect to the current evidence and recommendations on alcohol misuse management in young people, while the initial impact of alcohol warning labels has not been sustained [41], integrated risk prevention campaigns, particularly school and family-based and multi-component interventions, have been found to be effective, although these are associated with small effect sizes [42–44]. There is also a clear benefit arising from increasing price and reducing availability of alcohol [45]. Interventions that reduce peer pressure or increase parental monitoring may potentially be effective [46]. Further, and importantly, Cohn and colleagues [13] have examined the potential use of mobile technology, which has already been implemented in health care (for example, in delivering recommendations or

appointment reminders to patients), to provide alcohol interventions and promote behaviour change to reduce harmful alcohol consumption. The authors concluded that the field of alcohol studies has yet to move into this domain as a method of preventing or treating alcohol problems, with the urgent need for engaging interactive media in supporting alcohol help-seeking. Communication of health risks via sonification (using sound to display data), music and interactivity may offer help in this respect.

3 Sound as a communication medium in health

In medicine, sonification has been studied in a number of contexts, for example, as an aid for analysis and diagnosis [47,48], as a potential aid in disease treatment [49], as help for paralyzed and visually impaired patients [50], and physiotherapy data display [51]. A more comprehensive overview of sonification applications in medicine can be found in [61]. To our knowledge this is the first study that uses sonification, music and interactivity to enhance the visual communication of alcohol health risks to young people. An extensive search of several research databases (CINAHL, Medline, Cochrane Library, PsycINFO, IEES, Web of Science, Science Direct, Project Muse and JSTORE) was undertaken by the authors up to April 2014 and identified no other studies in this area. Inclusion criteria involved studies of any design on sonification and health risk communication in relation to alcohol use in young people published in English. As previously mentioned, sonification, music and interactivity have the potential to be highly engaging for young people. Interactive media, of which interactive sonification is a sub-type, allow multiple presentation modes (e.g. text, narration, video, graphics, music), facilitating multi-sensory stimulation (e.g. sight, sound, colour, movement and reading) and for quick customisation of messages in order to appeal to specific audiences [52].

4 The SCORe project

Building on a previous multidisciplinary project titled *Jane's story-Chronic health issues of adolescents: is the world listening?*, which employed the communicative qualities of sound and music to communicate health issues, we hypothesised that a combination of film music techniques and sonification may influence how effectively and accurately one recalls information and potentially increase engagement (i.e. interested involvement) with a visual presentation of data. We created a visual-only presentation of alcohol health risk data (control condition V-Cont) and augmented it in two ways: by adding simple interactivity, i.e. by clicking on objects, aspects of the presentation are highlighted or revealed (experimental condition VI-Exp) and by adding audio (sonification and music) and interactivity (experimental condition VAI-Exp). Thus, our objectives in the SCORe Project: using Sonification to COmmunicate public health Risk data were:

1. To evaluate how effectively and accurately a user recalls the information presented in the two experimental conditions VI-Exp and VAI-Exp as compared to the control condition V-Cont;
2. To test whether conditions VI-Exp and VAI-Exp lead to a more enjoyable experience for the user as compared to the control condition V-Cont.

5 Experimental method

5.1 Design

A 3-arm pilot trial was conducted at the Department of Theatre, Film and TV, University of York, in the period October 2014–January 2015. The study was approved by the Research Ethics Committee of the Department in July 2014. Participants were free to withdraw from the experiment at any time without providing a reason. All participants provided a signed consent.

5.2 Participants

We excluded University students from disciplines such as music, health sciences or theatre, film and television, in case these areas of study introduced a bias. The inclusion criteria were: being a university student; being aged 18–25 years; having the ability to consent. All participants reported normal hearing. Participants basic characteristics are presented in Table 1.

5.3 Intervention

The basic visual presentation was created in PowerPoint 2011 and it was designed around the information provided by Alcohol Concern Factsheet 2011 [53], the National Health Service [22], and a number of scientific articles and reports [21,53–55]. The presentation used in this trial represents the first prototype of an application that could be programmed as an

Table 1 Participants characteristics

Variables N of subjects	V-Cont n = 32	VI-Exp n = 32	VAI-Exp n = 32
Age, mean (SD)	20.6 (1.7)	20.2 (1.9)	19.9 (1.5)
Female, n (%)	22 (68.8)	16 (50)	23 (71.9)

app for smart phones and tablets, or as an interactive website. During the development of the intervention, we ran a small pilot with seven people to test the readability and intelligibility of the intervention and to test the questionnaires. The feedback from this small test informed the design of the final intervention and the final version of the questionnaires. The final intervention included slides with text only, images and data, different types of graphs such as bar graphs and line graphs—see online resource OnRes2. The visual appearance aimed to be clear, concise, and unified in style and colour palette. The design was minimalistic and in line with the recent trends in graphic representation. The colour palette was based on green, blue and white. The presentation consisted of eleven slides in total. In condition VI-Exp five slides (numbers 3, 4, 5, 6, 8) had interactive elements. In condition VAI-Exp, all slides had a musical accompaniment and five slides (same numbers as above) had interactive and sonified elements. In these five slides the user could interact with images, data and graphs (for example the image of a pint of beer), with the effect of visually highlighting or revealing related information (for example the alcohol units) in condition VI-Exp, and also trigger appropriately designed sonifications and music (for example an auditory icon designed to represent the drink and its alcohol units) in condition VAI-Exp. The sonification designs were created to best complement the content of the slides on alcohol health risks. A variety of sonification techniques such as parameter mapping [56] and auditory icons and earcons [57,58] were utilised. The sonification design was integrated with music so that, together, music and sonification designs could communicate complementary messages: the emotional and metaphorical content (music) as well as the more literal information of the data (sonification). The music component was based on functions of film/media music identified by cognitive psychology and musicology researchers as effective in communicating information and improving the interpretation of a message [59,60]. The music was used in three distinctive ways: (1) as an overall support for the sonification, creating an emotional context; (2) as a continuity component, binding the presentation together; (3) as an interactive accompaniment, linked to sonification, and responding to participants actions. The music was composed using a number of self-contained modular components (short musical extracts that can be combined in many different ways), allowing for the structural flexibility needed to complement the needs of interactivity (being able to rapidly switch to a new slide and its music, or a new visual object and its sonification). These music modules included drones, drones with a distinctive rhythmic element, percussion loops, short melodic phrases, and various ostinati structures. A static-like noise was either incorporated into the arrangement of the pieces or appeared independently in situations where there was no music in the background. This allowed a musical binding element throughout the presentation, and also represented the toxic nature of alcohol (static-like noise can represent something not working properly). Generally, the music was meant to affect the participants more on a subconscious level, rather than in an explicit way (as music often does in film). However, there are instances (see in section 5.4 for example the music created for the sonifications of slides 4 and 8) in which the music was designed to grab the participants attention directly. In conditions VI-Exp and VAI-Exp, a number of simple ways to interact through the mouse, with the visual objects, music, sonification and slides were provided. In VI-Exp, clicking a visual object would either reveal information about that object (for example, clicking on the image of a drink would reveal the alcohol units in that drink), or highlight in red the information related to that object (for example, clicking on a body organ would highlight the short-term consequences of alcohol abuse). The subject was able to repeat this interaction as many times as wanted and in any order. In VAI-Exp, which included music and sonification, the interaction also allowed: (1) repeated listening (each sonification of drinks or other objects or data could be listened to more than once); (2) single data point listening (each data point of a bar graph can be heard separately); (3) the choice of listening order (the user could decide in which order to listen to the sonification elements present in each slide). The slides without interaction and sonification designs provided the user with basic information (for example the presentation title, definition of alcohol, information about helplines) and featured background music linking together the presentation (see the intervention video, OnRes3, in online resources). The modular nature of the music, often based on the principle of variation, in which the same material is repeated but altered in melody or rhythm or other musical characteristics, allowed the user to switch at any point to the next slide without creating discontinuity. The music from one slide blended seamlessly to the music of the next to create a sense of progression. More details on the creation of the music for non-interactive slides are discussed in [61].

5.4 Sound design and interaction

In conditions VI-Exp and VAI-Exp five slides included sonification and interaction elements (in condition V-Cont these slides were non-interactive and silent). Here follows a description of these slides in VAI-Exp. See online resource OnRes2 for figures of slides.

Figure 3 (OnRes2) provides information about standard alcohol units and links it to standard drinks in the UK. By clicking on the icon of the chosen drink (pint of cider or gin and tonic), participants reveal the alcohol unit content for the selected drink, and trigger the appropriate auditory icon (see OnRes3). The auditory icons designed for the drinks reflect the type of alcoholic beverage, and their duration is

directly related to the alcohol unit content. For instance, the first drink, a glass of gin and tonic (1 unit of alcohol), is three times shorter than a pint of cider (3 units of alcohol). The sounds of the drinks blend the natural sound characteristic of a particular drink with appropriate musical sounds that can fit with the background music as well as symbolise the drink (e.g. the sound of the ice cubes in a glass are mixed with a glassy, bell-like percussive sound to represent a glass of whiskey). All drink sounds are in the A minor key, tuned to the background music which is intentionally simple to allow the user to focus on the sonification designs.

Figure 4 (OnRes2) provides information about binge drinking in Europe. The slide presents the map of Europe with countries marked by different colours, which reflects the binge-drinking levels expressed in percentages. By clicking on a country on the map, the participant triggers a musical sonification (see OnRes3), whose complexity and amount of distortion are linked to the percentage of binge drinking for that country (the higher the binge drinking percentage the more complex and distorted the music). Musical sonification designs are inspired by club music (dub step style) given the connection between binge drinking and clubbing and other types of young peoples social activities.

Figure 5 (OnRes2) presents a bar graph comparing girls and boys alcohol consumption at different ages. This slide features a drone, which provides a neutral background for the sonification of the bar graph. The sounds used for the sonification of the bars combine two elements: a short sound with a fast attack and the reversed variant of the same sound. The bars showing boys alcohol consumption are represented by a single piano note (A natural) in a low register, whereas girls drinking is sonified with a violin sound (A natural) in a higher register. This pitch mapping relates to the fact that men have usually a lower pitched voice than women. Gender is mapped to two different instruments, piano and violin, which are very well known instruments, recognisable and different. The length of the sounds reflects the increase of alcohol consumption with age. The sounds are triggered by clicking on the bars (see OnRes3).

Figure 6 (OnRes2) is dedicated to the short-term consequences of alcohol use. This slide features a human body with visible organs. The idea for the sonification of this slide was to show what happens when alcohol enters the body. By clicking on the organs we can listen to a sonification of the impact of alcohol consumption on that organ (see OnRes3). All the sounds used in this slide can be divided in two major categories: (a) those directly connected to the organ, for example, heartbeat for heart, breathing for lungs, etc.; (b) those indirectly connected to the organ function, for example kidneys or liver. The sounds belonging to the first category are created by selecting the natural sound associated with the organ and applying various processes to it (for example addition of a reverb or a flanger effect). The sounds from the second category are created by blending together various natural and synthesized sounds from sources that have a metaphorical association with the organ. For example, the sounds of organs such as liver, kidneys and the stomach are created by combining sounds of various home appliances, e.g. a blender or a washing machine, with watery sounds produced by boiling water or a pitch-shifted running water sound. Some organs, for example the brain, are sonified using different virtual synthesizers. Additionally, many of the internal organs feature static-like or metallic drops sounds to emphasise the toxic nature of alcohol. This type of sound is particularly noticeable in the sound representing alcohol spreading through the body through the vascular system.

Figure 8 (OnRes2) focuses on liver cirrhosis mortality in England and Wales, Scotland and European countries, between 1950–2002. It contains two graphs, one for men and the other for women. The sonification design uses a combination of sampled orchestral string drones, glissandi, accelerando, diminuendo percussive effects, and piano passages that roughly follow the lines of the graph (see OnRes3). This approach produced short sonoristic musical pieces, a few seconds long for each line. The pitch and the intensity of the sound are associated with the increase or decrease in the mortality rates. This, in turn, results in what could be described as a cinematic effect, which is more musical than previous attempts at a more precise sonification (literally mapping the graph data to characteristics of a sound), but also represents well the data direction (for instance the sharp increase in mortality rate for Scottish men) in the graphs, and gives depth (given the aforementioned cinematic effect) to the traditional two-dimensional graph. As in slide 5, the low register is associated with men and the higher register with women.

5.5 Procedure

Participants were recruited through advertisements distributed via university emails. Interested participants were sent the information, consent form and a demographic questionnaire. They were invited to attend on a scheduled date and were then randomly assigned to one of three groups. Participants were then asked to complete a questionnaire that included questions on alcohol knowledge and alcohol risk perception. The intervention to which they had been allocated was then displayed to them. V-Cont group participants watched the visual only presentation on alcohol related risks. VI-Exp group participants experienced the visual presentation with interactivity. VAI-Exp group participants experienced the visual presentation with audio (sonification and music) and interactivity. For all groups the presentation was shown on a screen using a projector connected to a computer running the intervention. The exper-

Table 2 Average exploration time in minutes:seconds– time (SD)

V-Cont	VI-Exp	VAI-Exp
03:38 (00:52)	04:07 (01:09)	06:48 (02:24)

The differences in average exploration times were significant $F(2, 95) = 35.298$ $p < 0.001$

iment was conducted in an acoustically treated room and using a stereo Dynaudio sound system.
Each participant answered a questionnaire before, just after the intervention and at one month follow-up. The duration of the experiment ranged from approximately 20 to 30 minutes (including completing the questionnaires). Before each experiment, the participants were briefed on the presentation, and, for groups VI-Exp and VAI-Exp, the nature of the interaction was explained. The slides containing interactive components were clearly marked with an oval icon indicating the object/objects that could be clicked on by the participant. Each participant could explore the intervention in their own time (see Table 2).

After completing the intervention, participants were asked to answer again the knowledge and risk perception questionnaires, plus a user experience questionnaire. After one month from the intervention, subjects were asked, via email, to answer for the third time the knowledge and risk perception questionnaires. Data from these documents (before, after and at follow-up) were then entered into the SPSS (IBM SPSS Statistic version 21) software. All participants received a 10 pounds Amazon voucher for their contribution.

5.6 Measures

Alcohol knowledge was the primary outcome measure of the experiment and was collected through a multiple-choice test. This tested information from the intervention on alcohol-related health risks using 10 questions with four options, only one correct (see Knowledge section in online resource OnRes1).

Risk perception was another primary outcome measure of the experiment. A question designed by the authors was asked about alcohol risk perception measured on a scale from 0 to 10, with 0 being the lowest possible risk and 10 being the highest risk (see Risk Perception section in OnRes1).

Additionally, basic information on alcohol consumption was collected using appropriate questions from the Youth Risk Behaviour Survey [62] (see Risk Perception section in OnRes1). Data on alcohol consumption was gathered to make sure that the three groups were similar in this respect. Alcohol consumption was not tested after the intervention or at follow-up.

Experience (secondary outcome measure) was evaluated via the questionnaire after the intervention. A series of 9–14 questions (tailored depending on the condition experienced) were asked in order to evaluate the experience with the intervention and, in particular, with the sonification, music and interaction components (see Experience section in OnRes1).

5.7 Sample size and power calculation

A sample size calculation was prepared for the primary outcome measure of knowledge. Given the lack of previous relevant studies, we assumed a mean of 5 at baseline (on the scale 0–10) and a standard deviation (SD) of 1, increasing to 6 (SD = 1) in the control group post-experiment.

When considering experimental condition VI-Exp and VAI-Exp versus the V-Cont condition, 16 participants in each group were required to have 80 % chance of detecting a statistically significant increase in knowledge at the alpha level of 5 %: from a mean of 6 in the control group to a mean of 7 in the experimental groups, with a standard deviation of 1. To allow for any missing data we doubled the sample size to 32 participants in each group.

5.8 Data analysis

Data are presented as means (standard deviations) and frequencies (percentages), depending on their distribution. Groups were compared on knowledge and alcohol risk perception at post-experiment and follow-up using the Analysis of Covariance (ANCOVA) with the adjustment for the baseline measures. All the assumptions were met. The secondary outcome measure of experience with the presentation was measured using a 5-point Likert scale (see example of experience question in 5.6) and open-ended questions at post-experiment time only. Groups were compared on these questions using the chi-square test, the ANOVA and a simple qualitative content analysis. A two-sided significance level of less than 0.05 was considered appropriate.

6 Results

Of 96 participants who answered questionnaires at baseline and post-experiment, 9 (9.4 %) were lost to follow up. 6 were lost in group V-Cont, 3 in group VI-Exp and 0 in group VAI-Exp. There was no sex, age or year of study difference between those who were lost to follow up. Those who left the study had a slightly better knowledge at the start of the study (although this was still not significant $p = 0.065$).

6.1 Knowledge

Knowledge (Fig. 1) improved significantly in the whole sample from baseline to follow up [$F(1, 85) = 7.44$ $p = 0.008$ Partial Eta Squared 0.080], although there was no group dif-

Fig. 1 Knowledge results

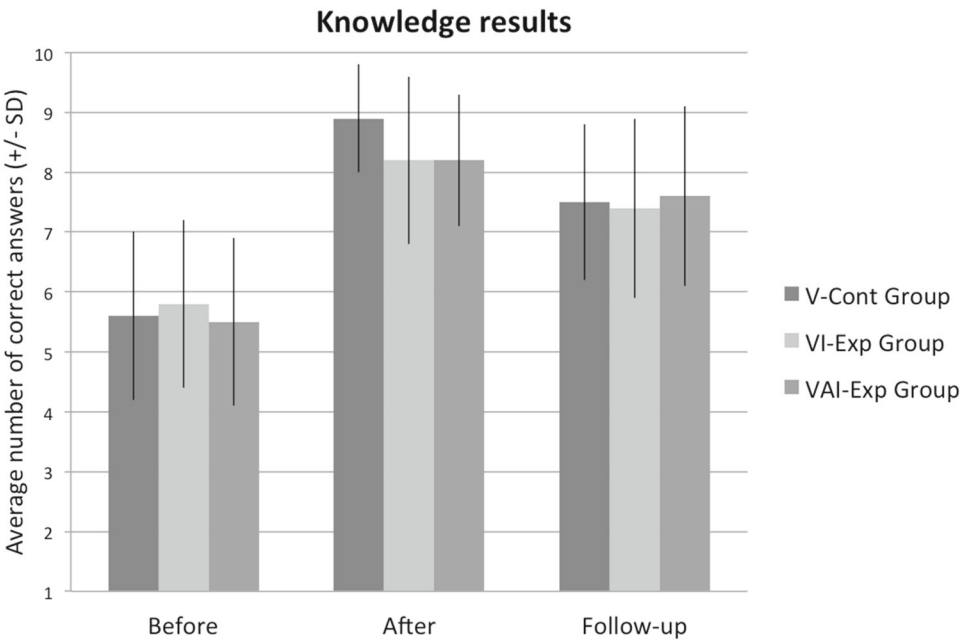
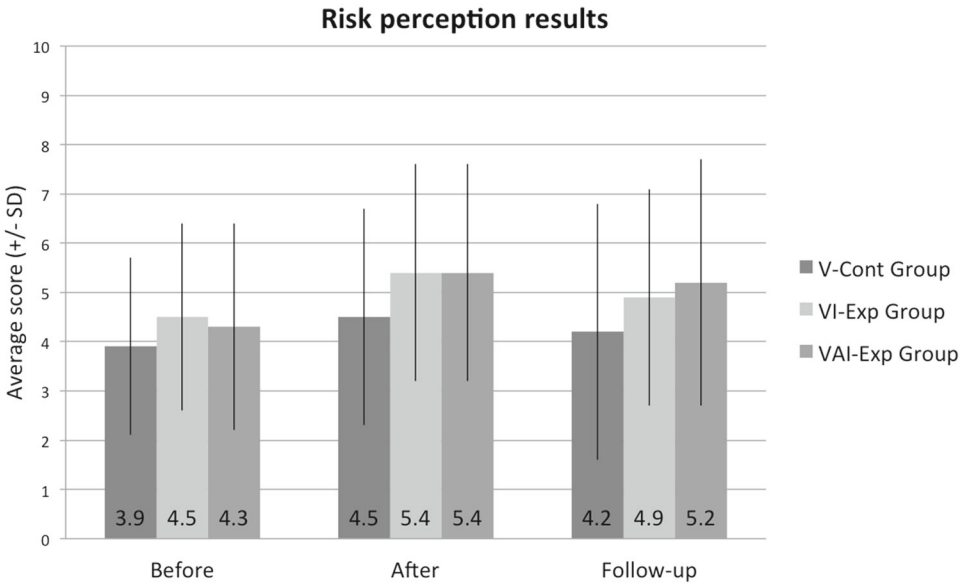


Fig. 2 Risk perception results



ference in knowledge improvement over time [(F (2, 83) = 0.232, p = 0.793, Partial Eta Squared = 0.006].

6.2 Risk perception

Risk perception (Fig. 2) improved significantly in the whole sample as above [F (1, 79) = 39.5 p < 0.001, Partial Eta Squared = 0.333], although, there was no group difference in risk perception over time [(F (2, 77) = 0.513, p = 0.601, Partial Eta Squared = 0.013]. Numerically, however, Group VAI-Exp was the one with the largest increase in alcohol related risk perception.

Table 3 reports alcohol consumption results (see Risk Perception section in OnRes1). These results show no statistical difference between groups.

6.3 Experience

The overall experience of the presentation was measured on a scale 0–10 (with 10 being the best experience). The mean score was 7.1 (SD = 1.2), indicating that participants enjoyed the intervention. The majority of the participants (96.9 %, 93 out of 96) also found the presentation educational (Table 4). There was no statistical difference between groups for experience results.

Table 3 Alcohol consumption results

Q2: N drinks in life (% subjects)				
<20(31.3)	20-39 (16.7)	40-99 (22.9)	> 100 (45.8)	
Q3: age of first drink (% subjects)				
< 13 (13.6)	13-14 (22.9)	15-16 (42.7)	≥ 17 (20.8)	
In past 30 days:				
Q4: N of days had at least 1 drink (% subjects)				
<2(20.8)	3-5(16.7)	6-9(38.5)	10-19(20.8)	≥20(0)
Q5: N days had 5 or more drinks (% subjects)				
0(37.5)	1-2(22.9)	3-5(19.8)	6-9(13.5)	≥10(4.1)
Q6: max n of drinks (% subjects)				
0(8.3)	1-2(10.4)	3-5(40.6)	6-9(35.5)	≥ 10(3.1)
Q7: where was alcohol bought (% subjects)				
store(54.2)	restaurant/bar/club(29.2)			
Q8: N of car rides, driver had drink (% subjects)				
0(91.7)	1(7.3)			
Q9: N of drives when had drink (% subjects)				
no car(77.1)	0(16.7)	1(5.2)		

Table 4 Experience results

Q9:Experience with intervention - mean(SD)			
All groups	V-Cont	VI-Exp	VAI-Exp
7.1(1.2)	6.7(1.2)	7.2(1.2)	7.3(1.2)
Q2:Was intervention educational - % of Yes			
All groups	V-Cont	VI-Exp	VAI-Exp
96.9	100	91	100
Q7:Quite or extremely effective (% of subjects)			
All groups	V-Cont	VI-Exp	VAI-Exp
71.9	68	74	72
Q8:It will impact my behaviour (% of subjects)			
Agreed or strongly agreed			
All groups	V-Cont	VI-Exp	VAI-Exp
34.4	40.6	28.1	34.4
Disagreed or strongly disagreed			
All groups	V-Cont	VI-Exp	VAI-Exp
25	28	22	22
Neutral			
All groups	V-Cont	VI-Exp	VAI-Exp
34.4	25	44	34

Participants indicated that they learnt about the alcohol content in various drinks, safety limits advised by the UK National Health Service (NHS) for men and women, the specific effects of alcohol on the body, the fact that young people in some countries are exposed to a greater risk of binge drinking than others, the mortality levels due to liver cirrhosis, and that the UK has a significant problem regarding the consumption of alcohol compared to other European countries.

The majority of the participants, 71.9 % (69 out of 96) found the presentation either quite or extremely effective in communicating alcohol related risks (Table 4). Regarding the impact of the presentation on the participants behaviour in relation to alcohol consumption, 33 (34.4 %) indicated that they either agreed or strongly agreed that the presentation would change their behaviour regarding alcohol intake, while 33 (34.4 %) participants neither agreed nor disagreed with the statement that the presentation would alter their alcohol-related behaviour. The remaining 24 (25 %) participants disagreed or strongly disagreed that the presentation would have any impact on their behaviour. Six subjects did not answer the question. In the last section of the questionnaire, subjects were asked to comment on a number of aspects of their experience. This qualitative data is very useful in understanding what worked and what did not work for any future implementations. In order to identify both the effective aspects and shortcomings of this intervention, results are analysed in terms of how the different versions of the intervention facilitated the users exploration, engagement, action and reflection with the information.

6.4 Exploration

The majority of V-Cont subjects praised the clarity of the intervention, the use of colour, images, graphs and text and the fact that it was easy to read. However they identified the lack of interaction as the main obstacle to a more interesting exploration. About a third of VI-Exp thought that the interactivity implemented here, though simple, allowed them to slow down, explore graphs in their own time and focus on the information more closely. Approximately 20 % of the group pointed out that the interaction was too limited, because it did not always result in new information being revealed. In only one slide would interacting with objects result in new information being revealed, in the rest interacting would simply highlight information already present in red. In group VAI-Exp, about two thirds of the subjects mentioned interactivity as very useful for exploration. Interestingly, in this version, interactivity always reveals new sonic information, since it triggers the sonifications. However, about a third of subjects found that the background music or the sonifications distracted them from exploring the content.

> *When a slide had general background music it helped, but when each thing you clicked on had different effects I found that a bit distracting []. [Subject: 081]*

6.5 Engagement

A few V-Cont subjects described the presentation as too impersonal, too matter of fact, simple and even boring. These observations almost disappear in comments from VI-Exp and

VAI-Exp, who instead describe the intervention as engaging and fun. About 60 % of participants of all groups suggested using video clips showing real cases of people affected by the misuse of alcohol. They also suggested that more shocking elements such as graphic images (e.g. liver cirrhosis, car accidents) needed to be added to increase engagement. Some subjects in VAI-Exp liked the use of music and sounds to provide this emotional layer without the use of graphics imagery, while a number of subjects found the music too dramatic or quite scary. Interactivity in VI-Exp and VAI-Exp is considered to be facilitating engagement. Slide 6, showing the short-term effects of alcohol on the body, proved to be particularly engaging for group VAI-Exp. Overall, 87 % participants indicated that sounds were appropriate in representing the effects of alcohol on body organs. It seems that this particular slide provided a well-balanced ratio between interactivity (clicking on the images of the human organs triggered a sonification of the impact of alcohol consumption on the organ) and the type of sounds created.

> *The heartbeat, the blood vessels, the lungs. The sounds of those organs in particular helped me to visualize the possible effects of alcohol misuse. [Subject: 021]*

Participants from V-Cont and VAI-Exp also suggested the use of narration (i.e. a voiceover presenting the content of the presentation) to facilitate the absorption of information.

6.6 Action

The ability to interact was considered positively by all the subjects. Although the only action required was clicking on objects, there were no comments about this. Additionally interaction was considered much more effective when it revealed information rather than just highlighted information. Indicating that the output of the interaction was perhaps more important than the complexity of the action.

6.7 Reflection

In terms of reflecting upon the information presented by the intervention, 72 % of VAI-Exp subjects indicated that the sounds, i.e. the music and sonification, helped in conveying the message.

> *The interactive sounds definitely had a great influence on the messages being portrayed, bringing the facts and figures to life. [Subject: 124]*

87 % of VAI-Exp considered the presentation effective in communicating alcohol-related risks.

> *I can definitely say that I learnt a lot [more] about alcohol in the span of approximately 20 minutes than I have since I began consuming alcohol. It was an easy-to-follow, highly informative presentation []. [Subject: 124]*

The relationship between the sonification and the data was perceived by the majority of the participants: 61 % observed this relationship in slide 3 drinks; 79 % in slide 4 binge drinking; 63 % in slide 5 consumption of alcohol; 90 % in slide 6 short-term consequences; and 79 % in slide 8 liver cirrhosis. However, despite the subjects finding the interactive and audio components generally engaging, there was no clear evidence that these components facilitated reflection on the information. For those subjects who perceived the music and sounds as too dramatic and intense these aspects were, in fact, distracting. More comments from the participants regarding the audio components of the intervention (i.e. sonification and music) are reported in [61].

7 Discussion and conclusion

The purpose of this study was to determine whether a visual presentation of alcohol health risk data augmented by simple interactivity, or sonification, music and interactivity could improve recall of alcohol-related health risk information, alcohol risk perception and increase engagement with the visual presentation of data. There is evidence that learning is improved when information is delivered in more than one mode [63]. We were unable to demonstrate this in our study. There was no statistically significant difference between groups in terms of quantitative results of health knowledge and risk perception. When we embarked on this project, no similar studies were available to inform our power calculations and consequently it is possible that we predicted a sample size too small for the effect that might exist. For this reason we suggest that future studies should consider using a larger sample size. Risk perception, however, significantly increased between the baseline and follow-up (but without significant difference between groups), indicating that the presentation was generally effective in raising awareness of alcohol risk. Interestingly, numerically, group VAI-Exp was the one with the largest increase in risk perception. We suggest that this trend could be further investigated in future larger studies.

In the experience section of the questionnaire, we asked participants to project how much impact this presentation would have on their attitude towards alcohol consumption: 34.4 % indicated a neutral influence of the presentation, 34.4 % indicated that their behaviour would change, while the 25 % said that it would not change their attitude towards alcohol. Other researchers have shown that while after a campaign students knew more about negative effects of binge drinking, this did not change their behaviour [65–67] and thus our results, even when self-reported and projected, are

consistent with this observation. We suggest that the social impact of drinking among university students, who were our population, should not be ignored and it may be the greatest challenge for researchers attempting to increase awareness of alcohol-related risks. Alcohol consumption is usually seen by young people as a positive experience which relates to having fun, conforming to peer group norms, forgetting everyday problems, feeling a sense of freedom, and boosting self confidence in social interactions [68–70] and therefore it is likely that young people strongly resist becoming aware of risks associated with alcohol.

It is perhaps in the more qualitative data produced by the experience part of the study that we can find the most important lessons to be learnt. The results showed that the whole sample had a good experience with the presentation. This encouraging outcome demonstrates that our approach of using multiple modes of communication is interesting to young people and worth replicating in future studies. We reported these results looking at the areas of exploration, engagement, action and reflection. With regard to exploration, participants considered interaction a key facilitator in exploring information. An important expectation of participants, one which we did not predict during the design of the intervention, was that an interaction should result in new information or new aspects of the intervention (for example sounds) to be revealed. When interaction was used to simply highlight existing information, participants considered the interaction somewhat redundant. Some participants reported that music and sonification helped them to focus and remember the displayed data. Others indicated that in some instances the music and sounds were distracting. It is clear that future designs should consider carefully the impact of sound on interaction and exploration of information, avoiding overloading people's perception and eliminating redundancy. There is a clear difference in engagement between V-Cont and VI-Exp or VAI-Exp. While a number of participants found V-Cont too impersonal and even boring, similar comments were very rare in the other two versions of the intervention which were instead described as engaging and fun. Some participants recognised and appreciated the emotional dimension provided by the music. Our intention in the creation of music and sonification design was to use a minimalistic approach in order to create minimal distraction. This proved a difficult balance to attain with some subjects still finding the music distracting and sometimes too intense or dramatic. Music appreciation varies depending on personal taste and experiences, so further work could look at ways of customising the type of music present in such an intervention.One suggestion is that music solely based on the timbre-orientated drones (which are free from harmony and rhythm) could facilitate a homogenous blend of music and sonification, allowing the latter to remain dominant and easily absorbed by the users.

Slide 6 (the short-term effects of alcohol on the body) was particularly successful in engaging the participants with the health information. This slide is perhaps the most inventive and original of all the slides in the presentation, and the one with the potential to be easily reinterpreted as an interactive installation or game where a user could see and listen to what is happening to the body and to particular organs when excessive alcohol is consumed. Additionally, about 60 % of participants suggested that using more drastic images could make the communication of alcohol risks more effective. Our intention was to design a presentation that would be informative and friendly, rather than threatening, or perhaps perceived as patronising, and thus we consciously decided not to add graphic content. It is, however, a known fact that young people prefer more explicit communication [64]. Consequently, in future intervention this element could be revised. A few subjects suggested that some of the information could be delivered in the form of an audio narration rather than by text, thus minimising the need for focusing on reading while also listening. Appropriate editing and mixing strategies would have to be implemented to ensure that speech did not interfere with music and sounds. With regard to action, although the interactivity in this presentation only required to click objects, subjects did not remark on the simplicity of the action as negative. The outcome of the interaction, however, had a great impact on exploration and engagement: subjects expected something new to be revealed as a result of interaction. This should be taken into account in new interventions.In terms of reflection, the majority of the subjects reported that the sounds played an important role in making the presentation effective, and a majority of subjects understood the relationship between the sounds and the data, although the intensity and nature of the music had a distracting effect for some. Future interventions should consider the effect of overlapping stimuli on the ability to reflect on information.

To conclude, we have presented one of the first studies on the use of sonification and music as support to health communication interventions, an important area of application for music and sonification. Despite the lack of significant results, perhaps due to the underestimation of the power needed for the study, this work will provide a model for the design of future studies in this area.

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References

1. Carney T, Myers BJ, Louw J, Okwundu CI (2016) Brief school-based interventions and behavioural outcomes for substance-using adolescents. Cochrane Database Syst Rev 1
2. Foxcroft DR, Moreira MT (2015) Almeida Santimano NML, Smith LA. Social norms information for alcohol misuse in university and college students. Cochrane Database Syst Rev 12
3. Weitzman ER, Nelson TF, Lee H, Wechsler H (2004) Reducing drinking and related harms in college evaluation of the a matter of degree program. Am J Prev Med 27(3):187196
4. Foxcroft DR, Lister-Sharp D, Lowe G (1997) Alcohol misuse prevention for young people: a systematic review reveals methodological concerns and lack of reliable evidence of effectiveness. Addiction 92(5):531–537
5. Stockley CS (2001) The effectiveness of strategies such as health warning labels to reduce alcohol-related harms an Australian perspective. Int J Drug Policy 12(2):153166
6. Viner RM, Taylor BJ (2007) Adult outcomes of binge drinking in adolescence: findings from a UK national birth cohort. Epidemiol Commun Health 61(10):902907
7. Crabbe JC, Harris RA, Koob GF (2011) Preclinical studies of alcohol binge drinking. Ann N Y Acad Sci 1216:24–40
8. Oster-Aaland L, Lewis MA, Neighbors C, Vangsness J, Larimer ME (2009) Alcohol poisoning among college students turning 21: do they recognize the symptoms and how do they help? J Stud Alcohol Drugs Suppl 16:122–130
9. Zeigler DW, Wang CC, Yoast RA, Dickinson BD, Mccaffree MA, Robinowitz CB et al (2005) The neurocognitive effects of alcohol on adolescents and college students. Prev Med 40(1):23–32
10. Newbury-Birch D, Gilvarry E, McArdle P, Ramesh V, Stewart S, Walker J (2008) Impact of alcohol consumption on young people: a review of reviews. Institute of Health and Society at Newcastle University, Newcastle upon Tyne
11. Beenstock J, Adams J, White M (2010) The association between time perspective and alcohol consumption in university students: cross-sectional study. Eur J Public Health 21(4):438–443
12. Clark C, Dugdale G (2009) Young peoples writing: attitudes, behaviour and the role of technology. National Literacy Trust, London
13. Cohn AM, Hunter-Reel D, Brett BT, Hagman T, Mitchell J (2011) Promoting behavior change from alcohol use through mobile technology: the future of ecological momentary assessment. Alcohol Clin Exp Res 35(12):2209–2215
14. Kasesniemi E (2003) Mobile messages: young people and a new communication culture. Tampere University Press, Tampere
15. Kramer G, Walker BN, Bonebright T, Cook P, Flowers J, Miner N (1999) The Sonification report status of the field and research agenda. Report prepared for the National Science Foundation by members of the International Community for Auditory Display. Santa Fe NM International Community for Auditory Display (ICAD)
16. Hermann T, Hunt A, Neuhoff JG (eds) (2011) The sonification handbook 363–398. Logos Verlag, Berlin
17. Dubus G, Bresin R (2013) A systematic review of mapping strategies for the sonification of physical quantities. PLoS One 8(12):e82491
18. North AC, Hargreaves DJ, ONeill SA (2000) The importance of music to adolescents. Br J Educ Psychol 70(2):255–272
19. Nuttall P (2007) Thank you for the music?. The role and significance of music for adolescents. Young Consum 9(2):104–111
20. WHO (2014) Global status report on alcohol and health. World Health Organisation, Geneva
21. Fuller E (ed) (2013) Smoking, drinking and drug use among young people in England in 2012. Leeds, Health and Social Care Information Centre, London
22. NHS (2011) Alcohol statistics, Scotland. NHS National Services, Edinburgh
23. Balodis IM, Potenza MN, Olmstead MC (2009) Binge drinking in undergraduates: relationships with gender, drinking behaviors, impulsivity and the perceived effects of alcohol. Behav Pharmacol 20(5–6):518526
24. Norman P (2011) The theory of planned behavior and binge drinking among undergraduate students: assessing the impact of habit strength. Addict Behav 36:502507
25. Sullivan K, Cosden M (2015) High school risk factors associated with alcohol trajectories and college alcohol use. J Child Adolescent Subst Abuse 24:1927
26. Jones L, et al (2007) A review of the effectiveness and costeffectiveness of interventions delivered in primary and secondary schools to prevent and/or reduce alcohol use by young people under 18 years old. Alcohol and schools: review of effectiveness and cost-effectiveness. Liverpool: NICE
27. Steinberg L (2007) Risk taking in adolescence: new perspectives from brain and behavioral science. Curr Dir Psychol Sci 16(2):55–59
28. Cohn LD, Macfarlane S, Yanez C, Imai WK (1995) Risk-perception: differences between adolescents and adults. Health Psychol 14(3):217–222
29. Slovic P (2000) What does it mean to know a cumulative risk?. Adolescents' perceptions of short-term and long-term consequences of smoking. J Behav Decis Mak 13:259–266
30. Velleman R (2009) Alcohol prevention programmes. A review of the literature for the Joseph Rowntree Foundation (part two). Joseph Rowntree Foundation, York
31. Hastings G, Brooks O, Stead M, Angus K, Anker T, Farrell T (2010) Alcohol advertising: the last chance saloon. BMJ 340:b5650
32. Hastings G, Sheron N (2013b) Alcohol marketing: grooming the next generation. BMJ 346:1227
33. Anderson P, de Bruijn A, Angus K, Gordon R, Hastings G (2009) Impact of alcohol advertising and media exposure on adolescent alcohol use: a systematic review of longitudinal studies. Alcohol Alcoholism 44(3):229–243
34. Morgenstern M, Isensee B, Sargent JD, Hanewinkel R (2011) Exposure to alcohol advertising and teen drinking. Prev Med 56:304308
35. Hastings G, Sheron N (2013) Alcohol marketing: grooming the next generation. BMJ 346:1–2
36. Grenard JL, Dent CW, Stacy AW (2013) Exposure to alcohol advertisements and teenage alcohol-related problems. Pediatrics 131(2):e369–e379
37. Patil S, Winpenny EM, Elliott MN, Rohr C, Nolte E (2014) Youth exposure to alcohol advertising on television in the UK, the Netherlands and Germany. Eur J Public Health 24(4):561–565
38. Chen M-J, Grube JW, Bersamin M, Waiters E, Keefe D (2005) Alcohol advertising: what makes it attractive to youth? J Health Commun 10:553565
39. Fleming K, Thorson E, Atkin CK (2004) Alcohol advertising exposure and perceptions: links with alcohol expectancies and intentions to drink or drinking in underaged youth and young adults. J Health Commun 9:329
40. Austin EW, Hust SJT (2005) Targeting adolescents? the content and frequency of alcoholic and nonalcoholic beverage ads in magazine and video formats november 1999–april 2000. J Health Commun 10:769785
41. MacKinnon DP, Nohre L, Pentz MA, Stacy AW (2000) The alcohol warning and adolescents: 5-year effects. Am J Public Health 90(10):1589–1594

42. Foxcroft DR, Tsertsvadze A (2011) A Universal family-based prevention programs for alcohol misuse in young people (Review). The Cochrane Library(9)
43. Foxcroft DR, Tsertsvadze A (2011) Universal multi-component prevention programs for alcohol misuse in young people (Review). The Cochrane Library, 9
44. Hale DR, Fitzgerald-Yau N, Viner RM (2014) A systematic review of effective interventions for reducing multiple health risk behaviors in adolescence. Am J Public Health 104:5
45. Torjesen I (2011) Safe drinking campaigns run by alcohol industry do not reduce consumption. BMJ 343:6634
46. Guerrini I, Quadri G, Thomson AD (2014) Genetic and environmental interplay in risky drinking in adolescents: a literature review. Alcohol Alcohol 49(2):138142
47. Ballora M, Pennycook B, Ivanov PC, Glass L, Goldberger AL (2004) Heart rate sonification: a new approach to medical diagnosis. Leonardo 37:41–46
48. Mihalasa G, Paralescub S, Miricaa N, Munteana D, Hancua M, Tudora A, et al (2012) Sonic representation of information: application for heart rate analysis. International conference of the European federation for medical informatics quality of life through quality of information, Pisa
49. Hinterberger T, Baier G (2005) Parametric orchestral sonification of EEG in real time. IEEE Multimedia 12(2):70–79
50. Berndt-Schreiber M, Lesinski W, Trzciakowski Image Data, Medicine Sonification In (2008) J Med Inform Technol 12:177–182
51. Pauletto S, Hunt A (2006) The sonification of EMG data. International conference on auditory displays, London
52. Rimal RN, Flora JA (2013) Interactive technology attributes in health promotion: practical and theoretical issues. In: Street RL, Gold WR, Manning TR (eds) Health promotion and interactive technology: theoretical applications and future directions. Routledge, New York, pp 19–38
53. Alcohol Concern, Factsheet: Alcohol Concerns information and statistical digest (2011). http://www.alcoholconcern.org.uk/wp-content/uploads/woocommerce_uploads/2014/12/Young-People-factsheet-Dec-2010. last Accessed 14 Nov 2015
54. Hibell B, Guttormsson U, Ahlstrom S, Balakireva O, Bjarnason T, Kokkevi A, Kraus L (2012) The 2011 ESPAD Report: substance use among students in 35 European countries. ESPAD, Stockholm
55. Leon DA, McCambridge J (2006) Liver cirrhosis mortality rates in Britain from 1950 to 2002: an analysis of routine data. Lancet 367:52–56
56. Grond F, Berger J (2011) Parameter mapping sonification. In: Hermann T, Hunt A, Neuhoff JG (eds) The sonification handbook 363–398. Logos Verlag Berlin GmbH, Berlin
57. Brazil E, Fernstrom M (2011) Auditory icons. In: Hermann T, Hunt A, Neuhoff JG (eds) The sonification handbook. Logos Verlag Berlin GmbH, Berlin, pp 325–338
58. McGookin D, Brewster S (2011) Earcons. In: Hermann T, Hunt A, Neuhoff JG (eds) The sonification handbook. Logos Verlag Berlin GmbH, Berlin, pp 339–362
59. Boltz MG, Schulkind M, Kantra S (1991) Effects of background music on the remembering of film events. Memory Cognit 19(6):593–606
60. Cohen AJ (1993) Associationism and musical soundtrack phenomena. Contemporary music review 9:163–178
61. Walus BP, Pauletto S, Mason-Jones, AJ (2015) Evaluating the use of sonification and music to support the communication of alcohol health risk to young people: initial results. International conference on auditory displays, Graz
62. Prevention C. f. D. C. a. (2014) 2013 State and local youth risk behavior survey. http://www.cdc.gov/healthyyouth/yrbs/questionnaire_rationale.htm. last Accessed 14 Nov 2015
63. Mayer R, Multimedia E (1997) Learning: are we asking the right questions? Educ Psychol 32(1):1–19
64. Casper MF, Child JT, Gilmour D, McIntyre KA, Pearson JC (2006) Healthy research perspectives: incorporating college student experiences with alcohol. Health Commun 20(3):289–298
65. Clapp JD, Lange J, Rssell C, Shillington A (2003) A failed norms social marketing campaign. J Stud Alcohol 64:409–414
66. Licciardone JC (2003) Perceptions of drinking and related findings from nationwide campuses study. J Am College Health 51:238245
67. Yu J, Evans PC, Perfetti L (2003) Attitudes toward seeking treatment among alcohol-using college students. Am J Drug Alcohol 29:671691
68. Coleman L, Cater S (2005) Underage risky drinking motivations and outcomes. Joseph Rowntree Foundation, York
69. Szmigin I, Griffinb C, Mistral W, Bengry-Howell A, Weale L, Hackley C (2008) Re-framing binge drinking as calculated hedonism: empirical evidence from the UK. Int J Drug Policy 19:359366
70. Spencer G (2013) The healthy self and risky young Other: young people's interpretations of health and health-related risks. Health Risk Society 15(5):449462