Oculus Rift 3D Interaction and Nicotine Craving: Results from a Pilot Study

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ABSTRACT
Virtual reality is a new technology used in the treatment of nicotine addiction that involves immersing smokers in environments with specific stimuli in order to reduce the level of craving. The present study aims to present a new virtual reality technology (in this case, Oculus Rift) used to assess craving of Romanian smokers. Results showed that smokers feel a higher craving after the exposure to virtual reality environments with specific stimuli than neutral stimuli.

Author Keywords
Smoking Addiction; Nicotine Craving; Virtual Reality; User Testing; Interaction Experiment; Oculus Rift.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Human Factors; Design.

INTRODUCTION
Nowadays technology is advancing fast, and the concept of virtual reality is no longer unknown for the general public. Most people have experienced 3D cinema. Also, younger people are informed of all the devices which can be attached to smartphones or computers. Although initially virtual/augmented reality technology was created for recreation, today it is use in various fields: medicine (Szekely & Satava, 1999), education (Pribeanu, Balog & Iordache, 2016), psychology (Riva, 2003). Two important characteristics of virtual reality should be emphasized: *immersion* and *presence*. The *immersion* consists of all design and technological means of surrounding an individual or group of users with a virtual context (a tridimensional computer-generated space). The *presence* is a sensorial (visceral) reaction to a convincing immersive user experience (i.e. the human body reacts instinctively to the virtual environment as though it is the real one).

One of the issues that come to the attention of specialists is tobacco consumption which is currently responsible for the deaths of 5 million people (Mathers & Loncar, 2006) worldwide each year, and many of these deaths occur prematurely and at a young age. In addition, passive smokers are affected and there are approximately 600,000 people who die from exposure to passive smoking (Oberg et al., 2011). If the number of smokers continues to rise, at the end of this century there will be around one billion deaths caused by smoking, most of them in medium or underdeveloped countries, and half of these deaths will occur before the age of 70 years (www.who.int/tobacco/global_report/2013/en/). Even if there are a lot of smokers looking to quit smoking, only a small proportion have come to succeed without relapses.

In Romania, the prevalence of tobacco consumption is 27% according to the Eurobarometer from 2014 (ec.europa.eu/public_opinion/archives/ebs/ebs_429_en.pdf), thus registering a decrease of 3% compared to 2012.

The Advantage of Romania compared to other European countries is that here is one of the highest percentages of people who never smoked, 60% (compared with the percentage of 54% across Europe). In contrast, Romania has one of the lowest percentages of people who have managed to quit smoking and continues to be abstinent, compared to other countries from Europe.

The present study aims to present a new virtual reality technology used to assess craving of Romanian smokers. In order to accomplish this goal, we designed various 3D environments to be explored by using Oculus Rift (Davis, Bryla, & Benton, 2015), a head-mounted display (HMD) which offers users a unique experience through the high level of immersion in virtual reality.

VR Applications in Psychology
Virtual reality (VR) is a concept that refers to artificial environments created by a computer system which can offer the user an almost real impression of physical presence.

The idea of virtual reality was first presented by Ivan Sutherland, in 1965: “make that (virtual) world in the window look real, sound real, feel real, and respond realistically to the viewer’s actions”. It has been a long time since then and a lot of research has been done in different fields. Another definition of virtual reality is offered by Cruz-Neira in 1993: “Virtual reality refers to immersive, interactive, multi-sensory, viewer-centered, three-dimensional computer generated environments and the combination of technologies required building these environments.”

One of the recent promising devices in this area is Oculus Rift (Davis, Bryla, & Benton, 2015), a personal headset especially designed for people who are interested in the 3D virtual reality, in general, and videogames, in particular. Oculus Rift allows its user to feel like they are actually in a virtual environment just by wearing it. The

screen displays two images adjacent to each other, one for the left eye and one image for the right eye. The combination of lenses is placed above the screen, enabling the zoom in-out and re-shaping the picture for both eyes, thereby creating a stereoscopic 3D image. These Rift devices monitor the wearer's head motions by the embedded sensor and accordingly adjust the image. The user's head movement is continuously analyzed and it is not necessary to use a mouse to control the direction of the view.

Using virtual reality in psychological studies

Besides the entertainment role, virtual reality has begun to play an important role in clinical psychology and it is used increasingly more often in treating phobias, eating behavior disorders, obesity, erectile dysfunction and posttraumatic stress disorder.

The main advantages of using virtual reality in clinical researches are: the potential of a precise control; the ability to adjust the virtual environments to the individual needs of the participants; the opportunity to expose the client to a particular environment that normally would not have access to, or would not be safe; providing increased confidentiality by replacing in vivo desensitization with virtual reality desensitization.

Until now, some researches were conducted in order to test the effectiveness of using virtual reality to treat various conditions: fear of height – Hodges *et al.* (1995), Emmelkamp *et al.* (2002); fear of flight – North, North, & Coble (1997); Rothbaum *et al.* (1996); Rothbaum *et al.* (2002); fear of driving – Wald, Taylor (2000); PTSD (Posttraumatic stress disorder) – Rothbaum, Hodges, Alarcon *et al.* (1999); eating disorders – Riva *et al.* (2001); sexual dysfunctions – Optale, Nasta, Marin, & Ipianon (2003); ADHD (Attention deficit hyperactivity disorder) – Rizzo *et al.* (2000); pain management – Hoffman *et al.* (2011); panic disorder and agoraphobia – Vincelli *et al.* (2003); social anxiety – Pertaub, Slater, & Barker (2001).

Virtual reality in nicotine dependence

Regarding smokers, there are already various studies who started to use virtual reality in order to develop strategies for nicotine cessation. They use cue exposure therapy, which involves a repeated exposure to stimuli which were previously associated with an addiction in order to extinct the conditioned response to those stimuli.

The argument for using exposure to stimuli to nicotine addiction is based on classical conditioning learning model. Nicotine is the unconditional stimulus and the effects of nicotine are the unconditioned responses. The conditions or contexts in which a person smokes very often become conditioned stimuli that determine the appearance of conditioned responses, and this leads to craving and nicotine consumption.

Craving is a state which is felt in all addictive behaviors and diseases, like drug use or gambling. This state can be regarded as a phenomenon, especially that many of the addicts invoke craving as a reason for encouraging addiction and as an excuse for treatment failure. Additionally, craving can be considered as a way to escape from painful reality (whether internal or external), so that the risk of relapse to addictive behaviors increase (Higley, Craney, Spadoni, 2011).

Some authors have identified a number of craving features (Nespor, Matanelli, Pekarkova, Gregor, 2011): (a) Craving is caused by specific stimuli and triggers that can be categorized into two main groups: internal (fatigue, pain, etc.) and external (for example, environment, straining situation, and others). Craving can be triggered also by negative stimuli (anger), as well as positive stimuli (joy). (b) Usually, craving is accompanied by subjective states as stress, tension and exhaustion. (c) When someone is experiencing craving, cognitive functions are altered, like the decision-making process. (d) When someone is experiencing craving, the ability of self-control is affected.

Although most cases, craving leads to maintaining the addictive behavior, it can also help to identify triggers, environments, specific stimuli that can contribute at the development of intervention strategies.

Various studies (Araujo, Oliveira, & Mansur, 2006; Araujo *et al.*, 2007; Cox, Tiffany, & Christen, 2001; Sayette *et al.*, 2000; Tiffany, Drobes, 1991) promotes the idea that the concept of craving is not just an intense desire to consume a substance, but it includes more elements like: the intention to satisfy a desire, the anticipation of the positive effects of substance consumption, avoiding negative symptoms of withdrawal.

Given that low levels of craving are considered to be predictors of long-term abstinence, the main goal of cue exposure therapy is to determine a decrease in the level of craving.

Several studies developed in this field (Baumann, Sayette, 2006; Bordnick, Carter, 2012; Rodrigues, Valverde, Maldonado, Ferrer-Garcia, Secades-Villa, 2012) concluded that virtual reality is able to recreate situations and everyday environments that are associated with smoking. These environments can be used in intervention programs that are based on cue exposure therapy.

Another interested direction of research is to use specific smoking cessation applications for mobile devices in order to self-track unhealthy behaviors or to unlearn smoking habits – for examples, see (Matei *et al.*, 2014). In this case, the presented information is only bi-dimensional, unless special devices like Google Cardboard are used.

DESIGN METHOD AND EXPERIMENTATIONS

Our project – currently available as a prototype – is using a truly immersive device to study the behavior of smokers in various 3D virtual environments.

The actual purpose is to test if the level of craving will increase when smokers will be exposed to a set of virtual environments (genuine 3D generated scenes) with specific stimuli *versus* virtual environments with neutral

stimuli by using the Oculus Rift Development Kit 2 computing device.

To ensure that all participants in our study will have the same meaning of the concept of craving, we operationalized it using a simple item: "*On a scale from 0 to 10, where 0 is no desire and 10 strong desire, how strong is your desire to smoke right now?*"

Technological considerations

Obviously, having a 3D-enabled device is not enough. Specific software able to create various 3D interactive scenes – in our case, familiar controlled VR environments for the target users (especially smokers) such as home apartment, office, café, and club – was developed by using the Unity game engine (https://unity3d.com/).

For user modeling, the persona method was adopted by following an ontological approach (Negru & Buraga, 2012).

To access various data regarding the user behavior (e.g., movements, object selected from a given environment), a service-oriented architecture was implemented.

This approach is enabling the researcher to study the correlation between the need to smoke and the context the person is in. Secondly, the modular architecture is suitable for further processing of gathered data, including statistics, complex visualizations, data mining, etc.

User testing phase

After the prototype of the 3D environment was completed, we conducted a user testing controlled experiment on a number of 9 subjects (post-graduate students, age between 22 and 42 years, only two smokers) during the lab classes of the *Human-Computer Interaction* discipline (http://profs.info.uaic.ro/~busaco/teach/courses/hci/) in the second semester of the 2015/2016 academic year, Master of Software Systems Engineering, at the Faculty of Computer Science, Alexandru Ioan Cuza University of Iasi, Romania.

The purpose of this test phase was to ensure us that the virtual environments are perceived to be realistic and we used the feedback in order to improve the technological aspects. Each person had to explore a set of 5 interactive scenes (home apartment – alone, home apartment – party, office, café, crowded noisy club) in 10—15 minutes, with external guidance at request – see Figure 1.

All these virtual scenes contain neutral stimuli and stimuli associated with smoking. Depending on each virtual environment, specific objects were designed (TV, tables, couch) and some objects that are related with smoking such as lighters, ashtrays, and cigarette packs. Several scenes also include computer-animated characters (Figure 2).

After finishing the testing of the 5 virtual environments, each participant was asked to complete a questionnaire and answer a series of questions about this experience. Participants had the opportunity to explore each scene separately, to view those objects and even to interact with some of the specific stimuli.

Figure 1. User testing session of interacting with Oculus Rift.

Figure 2. Various interactions within the café 3D scene.

The most significant results regarding the assessment procedure of the user experience with the VR environments are available in Table 1.

Pilot study

The actual study consisted of the main phases depicted by Figure 3.

Participants

Daily smokers were invited to attend a testing session with the Oculus Rift virtual reality system.

In order to participate in this experimental session, smokers had to be 18 years old and had to be at least one-year smoker.

Items of the questionnaire	Result
Already interacted with Oculus Rift	Yes – 2 persons No – 7 persons Other form of VR interaction (Google Cardboard) – 3
Feeling of presence (immersion, embodiment)	Average score: 6.67 (on 1—10 scale)
Number of specific stimuli	Average score: 7.44 (on 1—10 scale)
Physiological side-effects	Vertigo – 2 persons Nausea – 2 persons; vomiting – 1 Fear – 2 persons Post-experiment reality perception difficulty – 1 Novelty-caused arousal – 1
VR design issues	• Difficult multimodal interaction (Rift + mouse) • Non-realistic 3D graphics, physical proportions and collisions, depicted scenery • Strange movements of computer-generated characters • Break-in-presence (Steed et al., 2005) • Too few stimuli for the actual participating smokers (2 of 9 subjects)

Table 1. Important user feedback concerning the VR design.

To recruit potential participants, we posted a message on a social network and those who were interested in this subject filled out a registration form with personal data.

A number of 48 people were scheduled for a testing session, but only 35 persons have successfully completed this task that lasted about 30 minutes.

Both men and women attended the testing session – from a demographic point of view, the average age was 30.2 years, all subjects were Romanian citizens and many of them were employed in a multinational IT company.

Procedure

The participants were informed at the beginning that they will test two virtual environments using Oculus Rift, because we want to observe differences in perceiving the virtual reality.

They had to smoke 30 minutes before starting the test. In the first stage, they were invited to become familiar with the VR device and they tested a virtual environment in the demo. After the adjustment phase, subjects had to complete a questionnaire – the Fagerstrom test – which measured their level of nicotine dependence.

It was found that most participants had an average level of nicotine addiction which means they are daily smokers, but the amount of nicotine consumed daily is not very high.

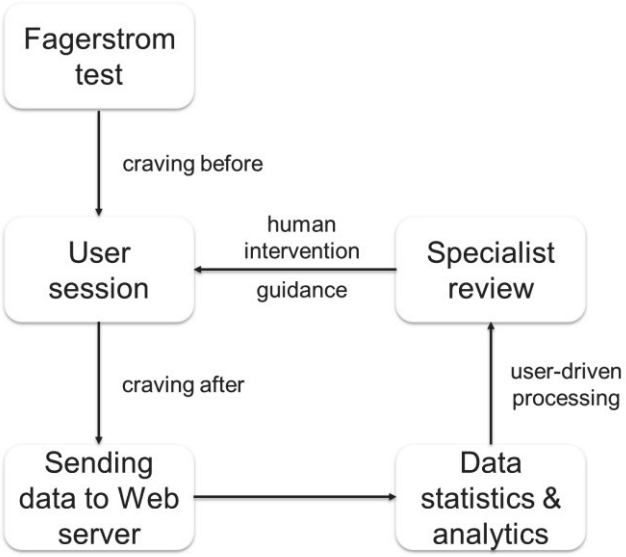

Figure 3. Main steps of the conducted pilot study.

Subjects were randomly distributed into two experimental groups:

Group I – those who started with the VR environment with specific stimuli (a fully 3D modeled apartment – Figure 4) and continued with neutral stimuli environment (forest – Figure 5).

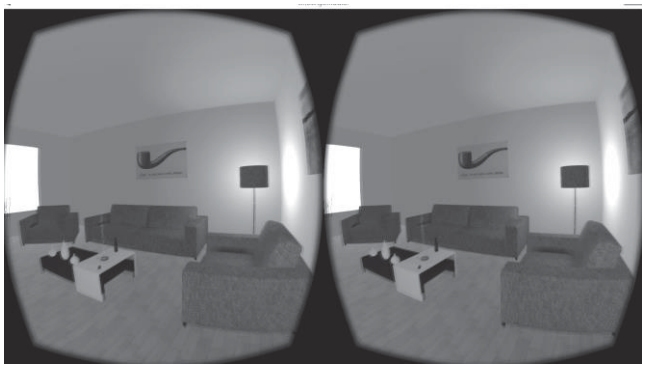

Figure 4. Specific stimuli 3D environment (as seen by the user interacting with the Oculus Rift device – left and right eyes).

Figure 5. Neutral stimuli 3D scene.

Group II – who started with the environment with neutral stimuli (forest) and continued with the environment with specific stimuli (apartment).

The apartment scene contains two rooms including a kitchen and a living room connected by a hallway. In each of these rooms there are some common items that can be found in any home: various pieces of furniture, TV, refrigerator, and in addition were placed a number of specific items which can be related to smoking – for example, packs of cigarettes, lighters, and ashtrays.

The forest scene was created exclusively with stimuli that are not directly related to smoking, especially to see if the perceived level of craving is different after the exposure to the apartment scene and the forest scene.

In order to simplify the pilot study, we chose that the other four designed environments will be used in further experiments.

The length of each exposure lasted between 5 and 7 minutes. Before and after each exposure, the subjects had to rate their level of craving using a visual analogue scale.

At the end of the exposure, the subjects had a debriefing phase, in which they were informed about the purpose of our study and had the possibility to tell how was that experience for them, because many of them have not tested Oculus Rift until then.

Results

We had 48 subjects that managed to complete all the phases from this process, but we had to exclude the data from
13 subjects due to initial confinement violation or due to the side effects of the exposure to virtual reality (e.g., nausea, headache).

Thus, results from 35 smokers entered in the statistical analysis. Of the subjects, 20 are men and 15 women.

To test whether there are differences between the initial level of craving and the level of craving after each exposure to virtual reality, we used ANOVA – analysis of variance (Bailey, 2008) method with repeated measurements and obtained an effect of $F(2, 68) = 33.32$, $p < 0.01$, which means that there are significant differences between the initial level of craving and the level of craving after exposure to the virtual apartment and after the virtual forest.

The Bonferroni Post Hoc Test (Bailey, 2008) showed that there are significant differences ($p < 0.01$) between the initial level of craving and the level of craving felt after the exposure to the virtual apartment, and between the level of craving felt after exposure to the virtual forest, meaning that subjects felt a higher levels of craving after the exposure to the virtual apartment environment (virtual environment with specific stimuli). No significant differences were found ($p = 1.00$) between the initial level of craving and the level of craving felt after the exposure to virtual forest environment.

In addition, we conducted similar analysis to capture the effect of gender on the level of craving felt by subjects from exposure to virtual environments.

Results emphasize that there is no significant interaction between gender and the level of craving experienced after the exposure to the VR scenes: $F(1, 33) = 0.04$, $p = 0.83$.

CONCLUSION AND FURTHER DIRECTIONS

As we expected, smokers have felt a greater need to smoke when they were exposed to virtual environment with specific stimuli compared to the virtual environment with neutral stimuli. These results are congruent with those obtained in other studies (Baumann, Sayette, 2006; Bordnick, Carter, 2008; Acker, MAcKillop, 2013; Gamilto *et al.*, 2011; Lee *et al.*, 2003; Paris et al., 2011; Pericot—Valverde *et al.*, 2011; Traylor *et al.*, 2009; Steed *et al.*, 2016) which showed that exposure to virtual environments with specific stimuli increases the level of craving felt by smokers. These results can confirm that a cue-exposure process can be a useful strategy in smoking cessation.

Smokers must face every day different situations that either cannot or should not be avoided. The majority of smokers affirm that the biggest difficulty in the process of quitting smoking is linked to the inability to resist, even if they are aware of the negative effects of this behavior. That is why craving is an important element of quitting strategies. Through cue exposure therapy, smokers are exposed repeatedly to smoking-related cues in order to reduce the reactivity.

The argument for using exposure to stimuli to treat nicotine dependence is based on the classical conditioning learning model.

Thus, in the nicotine addiction, the nicotine is an unconditional stimulus and the effects of nicotine are the unconditioned responses. The conditions or contexts in which a person smokes very often become conditioned stimuli that determine the appearance of conditioned responses, and this leads to craving and nicotine consumption.

Given that low levels of craving are considered to be predictors of long-term abstinence (Shiffma, Ferguson & Gwaltney, 2006; Killen & Fortmann, 1997), the main goal of cue exposure therapy is to determine a decrease in the level of craving.

Regarding the limitations of this study, we can mention that we had a reduced number of participants, which does not allow us to extend the results obtained so far. It would have been useful to have participants at this study with different levels of nicotine addiction to see if the perceived level of craving after the exposure to specific stimuli would be different.

From the human-computer interaction point of view, we used in this pilot study a novel virtual reality device – Oculus Rift, and it has been proven that it can be used in our research field.

We aim to investigate more realistic VR interactions that contain specific stimuli for smokers, and then to implement an intervention program based on cue exposure therapy using virtual reality for smokers who want to quit.

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REFERENCES

1. Acker, J. and MacKillop, J. Behavioral Economic Analysis of Cue-Elicited Craving for Tobacco: A Virtual Reality Study. *Nicotine Tab. Res*. 15, (2013), 1409-1416.
2. Araujo, R. B., Oliveira, M. S. and Mansur, M. A. Brazilian Validation of the Questionnaire of Smoking. *Cad Saude Publica*., 22 (10), (2006), 2157-2167.
3. Araujo, R. B., Oliveira, M. S., Moraes, J. F., Pedroso, R. S., Port, F. and Castro, M. G. Validation of the Brazilian Version of Questionnaire of Smoking Urges- Brief. *Rev Psiquiatr Clin*., 34 (4), (2007), 166-175.
4. Bailey, R.A. *Design of Comparative Experiments*. Cambridge Press, 2008.
5. Baumann, S. B. and Sayette, M. A. Smoking Cues in a Virtual World Provoke Craving in Cigarette Smokers. *Psychology of Addictive Behaviors* 20 (4), (2006), 484-489.
6. Bordnick, P. S., *et al.* A Feasibility Study of Virtual Reality-Based Coping Skills Training for Nicotine Dependence. *Research on Social Work Practice*. 22 (3), (2012), 293-300.
7. Cox, L. S., Tiffany, S. T. and Christen, A. G. Evaluation of the Brief Questionnaire of Smoking Urges (QSU brief) in Laboratory and Clinical Settings. *Nicotine Tob Res*. 3 (1), (2001), 7-16.
8. Cruz-Neira, C. Virtual Reality Overview. *SIGGRAPH'93 Course*. No. 23, 1993.
9. Davis, B. A., Bryla, K. and Benton, P. A. *Oculus Rift in Action*. Manning, 2015.
10. Emmelkamp, P. M., *et al.* Virtual Reality Treatment versus Exposure in Vivo: A Comparative Evaluation in Acrophobia. *Behaviour Research and Therapy*. 40 (5), (2002), 509-516.
11. Gamito, P., *et al.* Virtual Reality Exposure on Nicotine Craving. *Stud. Health Technol. Inform*. 167, (2011), 63-68.
12. Garcia-Rodrigues, O., *et al.* Validation of Smoking Related Virtual Environments for Cue Exposure Therapy. *Addict Behav*. 37 (6), (2012), 703-708.
13. Heatherton, T. F., Kozlowski, L. T., Frecker, R. C. and Fagerstrom, K. O. The Fagerstrom Test for Nicotine Dependence: a Revision of the Fagerstrom Tolerance Questionnaire. *British Journal of Addiction*, 86, (1991), 1119-1127.
14. Hodges, L. F., *et al.* (1995), Virtual Environments for Treating the Fear of Heights, *IEEE Computer*, 28 (7), 27-34.
15. Hoffman, H. G., *et al.* (2011). Virtual Reality as an Adjunctive Non-Pharmaceutical Analgesic for Acute Burn Pain during Medical Procedures. *Ann Behav Med*. 41 (2), 183-191.
16. Higley, A. E., Crane, N. A. and Spadoni, A. D. Craving in Response to Stress Induction in a Human Laboratory Paradigm Predicts Treatment Outcome in Alcohol-Dependent Individuals. *Psychopharmacology (Berl)*. 218 (1), (2011), 121-129.
17. Killen, J.D., Fortmann, S.P. Craving Is Associated with Smoking Relapse: Findings from Three Prospective Studies. *Exp Clin Psychopharmacol*. 5 (2), (1997), 137-142.
18. Lee, J.-H., *et al.* Experimental Application of Virtual Reality for Nicotine Craving through Cue Exposure. *Cyberpsychol. Behav.* 3, (2003), 275-281.
19. Mathers, C. D., Loncar, D. Projections of Global Mortality and Burden Disease from 2002 to 2030, *PloS Medicine*, 3 (11), 2006.
20. Matei, S. et al. Refreshing Quantification and other Ploys to Give Up the Habit. *Lecture Notes in Computer Science* 8512, Springer, (2014), 265-276.
21. Negru, S., Buraga, S. A Knowledge-Based Approach to the User-Centered Design Process. *Communications in Computer and Information Science*, Volume 415, Springer, (2012), 165-178.
22. Nešpor, K., Matanelli, O., Pekárková, G. and Gregor, P. Classification of Anticraving Techniques, *Prakt. Lék*., 91 (12), (2011), 703-706.
23. North, M. M., North, S. M. and Coble, J. R. Virtual Reality Therapy for Fear of Flying. *American Journal of Psychiatry*, 154 (1), (1997).
24. Oberg, M., *et al.* Worldwide Burden of Disease from Exposure to Second-Hand Smoke: A Retrospective Analysis of Data from 192 Countries. *The Lancet*, 377 (9760), (2011).
25. Optale, G., *et al.* Male Sexual Dysfunctions and Multimedia Immersion Therapy. *CyberPsychology & Behavior*, 6 (3), (2003), 289-294.
26. Paris, M., *et al.* Cue Reactivity in Virtual Reality: the Role of Context. *Addict. Behav*. 36, (2011), 696-699.
27. Pericot-Valverde *et al.* Evolution of Smoking Urge during Exposure through Virtual Reality. *Stud. Health Technol. Inform.* 167, (2011), 74-79.
28. Pertaub, D. P., Slater, M. and Barker, C. An Experiment on Fear of Public Speaking In Virtual Reality. *Studies in Health Technology and Informatics*, 81, (2001), 372-378.
29. Pribeanu, C., Balog, A. and Iordache, D. Measuring the Perceived Quality of an AR-based Learning

Application: a Multi-Dimensional Model. *Interactive Learning Environments*, (2016), 1-14.

30. Riva, G. Virtual Environments in Clinical Psychology. *Psychotherapy: Theory, Research, Practice, Training*, 40 (1-2), (2003), 68-76.
31. Rizzo, A., *et al.* The Virtual Classroom: A Virtual Reality Environment for the Assessment and Rehabilitation of Attention Deficits. *Cyberpsychology & Behavior*, 3, (2000), 483–499.
32. Rothbaum B.O., *et al.* Virtual Reality Exposure Therapy in the Treatment of Fear of Flying: A Case Report. *Behaviour Research and Therapy*, 34 (5-6), (1996), 477-481.
33. Rothbaum, B.O., *et al.* Twelve-Month Follow-up of Virtual Reality and Standard Exposure Therapies for the Fear of Flying. *Journal of Consulting and Clinical Psychology*, 70 (2), (2002), 428-432.
34. Rothbaum, B.O., *et al.* Virtual Reality Exposure Therapy for PTSD Vietnam Veterans: A Case Study. *Journal of Traumatic Stress*, 12 (2), (1999), 263-271.
35. Sayette, M. A., Shiffman, S., Tiffany, S., Niaura, R., Martin, C.S. and Shadel, W. The Measurement of Drug Craving – Methodological Approaches to Craving Research. *Addiction*. 95, (2000), 189-210.
36. Shiffman, S., Ferguson, S. G. and Gwaltney, C. J. Immediate Hedonic Response to Smoking Lapses: Relationship to Smoking Relapse, and Effects of Nicotine Replacement Therapy. *Psychopharmacology (Berl)*. 184 (3-4), (2006), 608-618.
37. Steed, A., et al. Breaks in Presence as Usability Criteria. HCI International 2005, the 11th International Conference on Human Computer Interaction, 2005.
38. Steed, A., *et al.* An 'In the Wild' Experiment on Presence and Embodiment using Consumer Virtual Reality Equipment. *IEEE Transactions on Visualization and Computer Graphics*, 22 (4), (2016), 1406-1414.
39. Szekely, G. and Satava, R. Virtual Reality in Medicine. *BMJ*, 319, (1999).
40. Sutherland, I. E. A Head-Mounted Three Dimensional Display. *AFIPS '68 Proceedings*. (1968), 757-764.
41. Tiffany, S. T. and Drobes, D. J. The Development and Initial Validation of a Questionnaire on Smoking Urges. *Br J Addict*. 86 (11), (1991), 1467-1476.
42. Traylor, A., *et al.* Using Virtual Reality to Assess Young Adult Smokers' Attention to Cues. *Cyberpsychol. Behav*. 12, (2009), 272-278.
43. Vincelli, F., *et al.* Experiential Cognitive Therapy in the Treatment of Panic Disorders with Agoraphobia: A Controlled Study. *CyberPsychology and Behavior*, 6 (3), (2003), 312-318.
44. Wald, J. and Taylor, S. Efficacy of Virtual Reality Exposure Therapy to Treat Driving Phobia: A Case report. *Journal of Behaviour Therapy and Experiential Psychiatry*, 31 (3-4), (2000), 249-257.