Evaluation of user satisfaction and usability of a mobile app for smoking cessation

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ARTICLE INFO

ABSTRACT

Background: Mobile apps have a great potential to support patients in healthcare, and to encourage healthy behavioral changes such as smoking cessation. Nevertheless, the user rejection levels are still high. A set of factors that has impact on the app effectiveness is related to the quality of those features that lead to positive user experiences when using the app. This work aims to evaluate the user experience, and more specifically the usability and the user satisfaction with a mobile application for smoking cessation. This will also provide a basis for future improvements.

Methods: We provided a smoking cessation mobile Android app to two different user cohorts, the smokers as valid users and the experts, for three weeks. The app featured usual functionalities to help quit smoking, including an achieved benefits section, mini-games to distract during cravings, and supportive motivational messages. We collected information about user experience, through game playability and message satisfaction questionnaires, and the experts' opinions. We also considered usage of app sections, the duration of the mini-game sessions, and the user ratings for motivational messages.

Results: We included 45 valid users and 25 experts in this study. The questionnaire indicated 80% satisfaction rate for the motivational messages. According to game questionnaires, over 69% of the participants agreed that the games have good usability features, however, for questions related to mobility and gameplay heuristics, agreements were below 67%. The most accessed app sections were achieved benefits and the one with motivational messages. The experts described issues that could help to improve the application.

Conclusions: The combination of questionnaires with expert reports allowed to identify several problems and possible corrections. Our study showed that motivational messages have a good satisfaction rate, although it is necessary to consider technical features of some mobile devices that may hinder message reception. Games have good usability and it's expected that the addition of difficulty levels and a better accessibility to the game menu could make them more attractive and increase its usage. Future development of mHealth apps based on gamification and motivational messages need to consider these factors for better user satisfaction and usability.

1. Introduction

Smoking is the one of the most preventable causes of morbidity and premature mortality in the world. The World Health Organization (WHO) recommends adding smoking cessation services in primary health care, however the traditional cessation programs require a lot of resources and many governments cannot cope with

those expenses [1]. Several studies have used smartphones to support smoking cessation behavior change [2–5]. Due to the ubiquity of smartphones and their widespread penetration [6], they can reach a high percentage of the population, and provide real-time and convenient support. The EU SmokeFreeBrain project investigates new methods for smoking cessation programs to improve their economical sustainability, including mHealth [7]. All the authors of the manuscript are researchers in this EU project.

However, despite the potential of apps to help stop smoking there is room for improvement regarding their user adherence [8,9]. According to a published research [10], approximately 800,000 quit-smoking Android apps were downloaded per month worldwide in 2012, and another study revealed that only 27 out of 83 iPhone apps for quitting smoking survived more than two years in 2012 [11]. This may be due to the fact that few health apps consider good practice guidelines [12]. US Clinical Practice Guidelines (USCPG) and behavior change theory-based therapies are the most recognized for smoking cessation interventions [2,13]. However, they only include recommendations to adapt multiple components to smoking cessation programs. Regarding apps, it is also necessary to assess the usefulness perceived by the users [14]. Attempts to design mHealth evaluation criteria are often too complex or too general to be able to adjust to the specific app functionalities [15–17]. In addition, it is more efficient to evaluate the user experience in the user's real environment – as this may change results significantly from those achieved with non-realistic scenarios [18–20]. Specifically, the user's perceived value and satisfaction are key factors for people accepting and engaging with these apps [21].

An alternative to evaluate these factors is to combine different methods depending on the application functionalities. In this study, we used a version of the Android app developed in the EU SmokeFreeBrain project [7], which featured an achieved benefits section, a set of mini-games to cope cravings, and a recommender-system based on motivational messages (Fig. 1). The authors participated in the design and development of this application. The aim of this study was to assess the user -satisfaction (in terms of usability and playability) with the developed smoking cessation app and to explore possible improvements. The study was carried out based on a combination of a set of heuristics specific for mobile games, the use of questionnaires and supplemented by additional information such as app usage analytics and reports from the participants. Among the numerous methods available for serious game evaluations [22], we chose heuristic evaluation [23], which has been considered a convenient method when applied by experts or technicians [24]. To evaluate the user satisfaction with motivational messages based on the app recommender system, we used a questionnaire, being one of the common practices [25,26], to analyze message ratings by the users within an app.

The study was approved by the ethics committee of TMU Joint Institutional Review Board (TMU-JIRB N201803083).

2. Methods

2.1. Procedure

Two cohorts were created to use the mobile app in a period of three weeks. The recruitment process consisted of locating volunteer university students in the field of health sciences and technology from the University of Seville (USE) in Spain; Aristotle University of Thessaloniki (AUTH) in Greece and Taipei Medical University (TMU) in Taiwan. The students were final year undergraduates or graduates who knew smokers in their immediate environment – family or relatives– that agreed to use the application during the established period. The students had a key role as participants and formed the first cohort– the experts–. They were not necessarily smokers but had enough knowledge in the area to assess the app

using an expert heuristic evaluation. The second cohort –named users– were smokers who used an Android smartphone and were recruited by each subject in the first cohort. Users were included based on their willingness to participate in the study if the age was 20 years and above. We use the term participants to refer to experts and users together.

The app includes different sections such as statistics showing achievements made by quitting, a message tray that contains the motivational tips received during a quitting attempt and a user profile information section (Fig. 1). A web server sends the motivational messages using a recommender system designed by Hors-Fraile et al. [27], which selects the most appropriate messages for each user. The app also includes three games called "Crash the cigarettes", "Blow the balloon" and "Physical Exercise", hereafter abbreviated as CCG, BBG and PEG, respectively. In CCG the user is asked to crush as many cigarettes as possible in 1 min while the time available for crushing a cigarette progressively decreases. This game was based on a study by Girard et al. [28]. BBG requires the user to blow air close to the smartphone's microphone only when the balloon's color is green to inflate it, which otherwise deflates quickly. The blowing intervals are based on a study by Jamalian et al. [29]. PEG consists of a set of physical exercises illustrated with videos, requiring the user to follow the presented physical activity.

Experts were informed about the steps required to properly use the app (Appendix A) and to set a quitting attempt date, which allowed to receive motivational messages. The experts in turn passed on this information to their recruited users. During the app configuration the user must answer some demographic data questions such as gender, date of birth, smoking habits, level of addiction (through the Fagerstrom [30]) test and level of motivation to stop smoking (through the Richmond [31] test). The first day of the follow-up period was set as the day on which the user completed all these steps. Each characteristic was evaluated through a series of questionnaires filled in outside the application (Appendix B, C) and with the usage information compiled by the application and sent to the web server. After the three-week testing period, we analyzed the usage of the application based on the number and duration of accesses to the different app sections and the participants' opinions about it.

2.2. Participants

A total of 25 experts, who recruited 88 users, participated in the study. Five users decided not to continue with the study or exceeded the established time to begin the follow-up period. Our protocol required that all participants had to start a quitting attempt, conduct a follow-up for three weeks and keep the quitting attempt during this period. After applying a hard filter criterion, 37 users were excluded for the following reasons (Fig. 2): (i) they did not fill all the required profile information in the app necessary to receive the messages ($n = 11$); (ii) they stopped or restarted their quitting attempt during the follow-up period ($n = 16$); (iii) or other technical issues which prevented them from receiving the motivational messages. ($n = 10$). All these events were planned to be excluded in the protocol as they reduced the number of messages received and they affected how the recommender system chooses and sends messages. However, we did analyze the incomplete data obtained from these cases, and found that it would have not provided significant information.

2.3. App behavior analysis

The data related to the number of visits to each section and the duration of these visits was collected by the app and stored in the
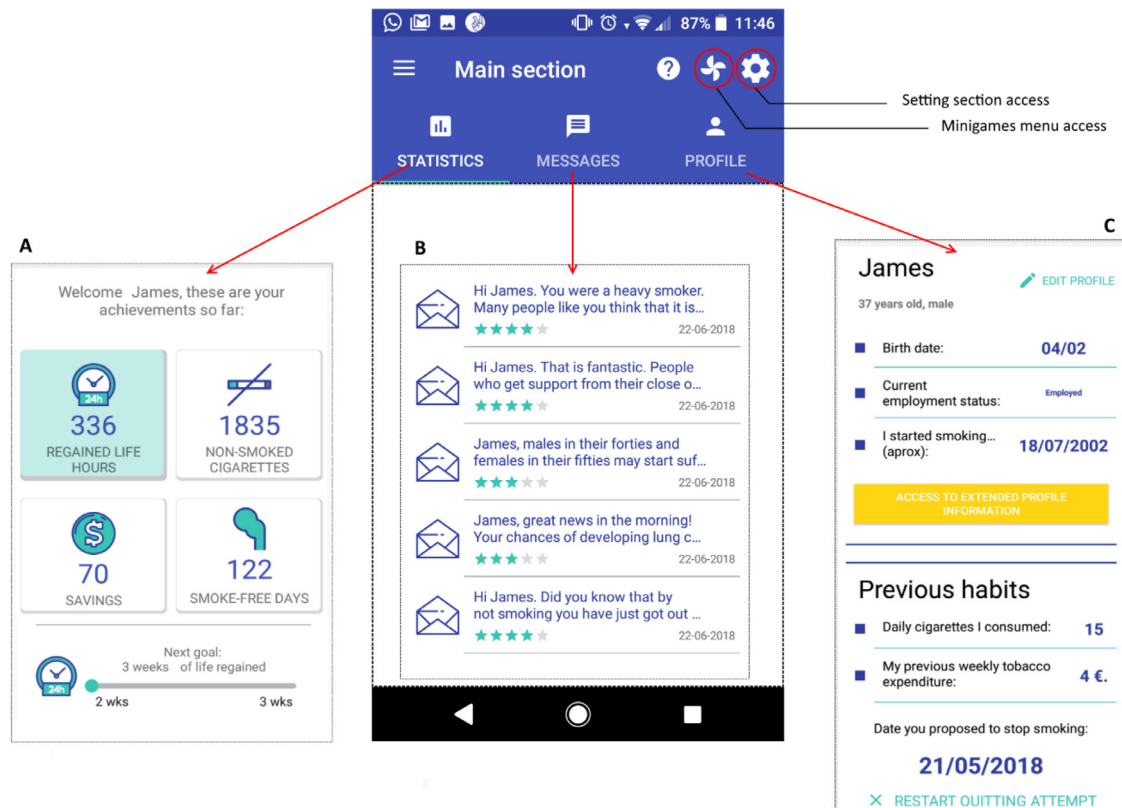
Fig. 1. App main sections. Achievements section (1A) reports the estimate of regained life hours from not smoking, both savings and non-smoked cigarettes calculated from previous user habits, and the number of days without smoking. Message tray (1B) allows to read and rate the received motivational tips, with a five-star score system. In the profile section (1C) the user can see and edit the information and establish a quitting attempt or restart it. Buttons at the top right allow access to the game menu and app settings.

server database. This data was used to detect the most used sections and their visit frequency. The data in the history of section accesses was filtered to eliminate outliers. The probability distribution curve of accesses durations (Appendix D) showed that there were some abnormal durations reported by our server. These reports broke the Gaussian probability distribution curve that could be expected for these values otherwise.

2.4. Game playability

A playability analysis of the games embedded in the app was carried out using data on game playing time, number of times each game was played, and the heuristics proposed by Korhonen and Koivisto [32]. This heuristic model consists of three modules that analyze the usability, the mobility and gameplay. The first module refers to technical factors that allow ease of use; the second is related to a how a game behaves in diverse environments, and the third refers to the game dynamics and those features that make a game more immersive. The original Korhonen's heuristics were analyzed to elaborate a questionnaire adapted to our app context. Appendix E shows the questions with the corresponding heuristic from Korhonen's proposal. Some questions were ruled out because they were not applicable to the implemented games. Most of these were not applicable due to the simple nature of games, the lack of history and the closed game dynamics –they all have a preset duration– and the final game score consisted of the number of failures and successes in CCG and BBG or the number of exercises performed in PEG. The heuristic that referred to whether standard conventions were followed was discarded since it could be confusing for the participants –there were two games with an unusual

playing mode (BBG and PEG) in opposition to CCG, which has a playing approach like that in many mobile applications–. After this step, we analyzed the questions based on whether they could be understood and answered by the users without providing detailed information. From this analysis we considered that there was a set of four heuristics that could be difficult to understand or in which a "Yes/No" answer could not provide enough relevant information. This set was answered only by the experts providing a detailed response. With the remaining heuristics we established a second set, to be answered by all the participants, as "Yes/No" questions. The questions of this second set were modified in a final phase to facilitate their understanding by the users.

2.5. Users' message satisfaction

We retrieved the number of read messages and ratings from the app, and gave the users a five-level Wuensch [33] satisfaction scale questionnaire (Appendix F) with values between "Totally disagree" and "Totally agree". The questionnaire was designed to assess the level of perceived value in the messages content, the adequacy of the messages to the user profile, and the messages general satisfaction level. The questionnaire was answered by each user at the end of every week for a duration of the study.

2.6. Expert reports

The experts could optionally provide their own comments highlighting positive, negative points and recommendations. The reports were analyzed to extract the main opinions. This approach
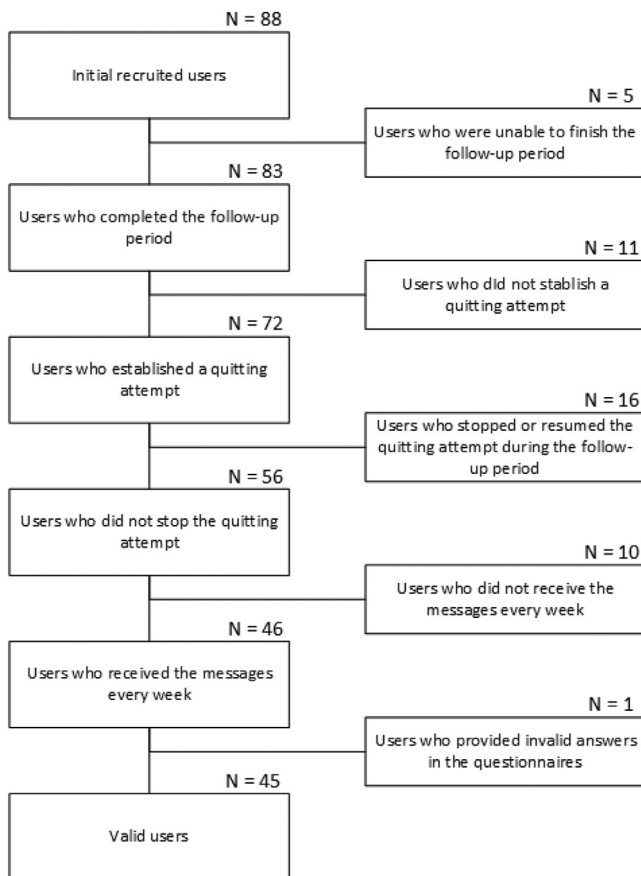
Fig. 2. Consort diagram.

Table 1
Baseline characteristics of the participants.

Experts	Value ($n = 25$)
Academic discipline	
Biomedical engineering	22
Healthcare sciences	3
Study level	
Undergraduate (final year student)	21
Postgraduate	4
Age in years, mean $\pm$ SD	24.32 $\pm$ 6.07
Female, n (%)	11
Users	Value ($n = 45$)
Age in years, mean $\pm$ SD	32.18 $\pm$ 2.75
Age category, n (%)	
<21 years	1 (2.2)
21–30 years	29 (64.4)
31–40 years	4 (8.9)
>40 years	11 (24.4)
Female, n (%)	18 (40.0)
Location, n (%)	
Asia	10
Europe	35
Employment situation, n (%)	
Employed	30 (66.7)
Unemployed	15 (33.3)
Fagerstrom test result, mean $\pm$ SD	2.82 $\pm$ 2.32
Fagerstrom test category, n (%)	
Low addiction level (0–3)	31 (68.9)
Medium addiction level (4–7)	11 (24.4)
High addiction level (8–10)	3 (6.7)
Richmond test result, mean $\pm$ SD	5.69 $\pm$ 2.64
Richmond test category, n (%)	
Low or no motivation (0–3)	8 (17.7)
Uncertain motivation (4–5)	12 (26.7)
Moderate motivation (4–7)	16 (35.6)
High motivation (8–10)	9 (20)
Daily consumed cigarettes, mean $\pm$ SD	12.15±7.16
Daily consumed cigarettes category, n (%)	
<8 cigarettes	12 (26.7)
8–14 cigarettes	21 (40.0)
15–21 cigarettes	13 (28.9)
>21 cigarettes	2 (4.4)

tried to locate important aspects that may have gone unnoticed with other information gathering methods [34].

3. Results

3.1. Overview

Table 1 summarizes the sample baseline variables. Users' mean age was 32.18 (SD 12.75), with a high percentage between 21 and 30 years old (64%), followed by those users older than 50 (24%). Two thirds of users were employed. The Richmond test showed that users had a widely distributed motivation to stop smoking. The Fagerstrom test results, as well as the consumed daily cigarettes, showed that the sample had a low to medium addiction level. As experts were students and not required to be smokers their smoking data was not requested.

3.2. Game playability

3.2.1. Usability heuristics and expert reports

Fig. 3a illustrates the questionnaire results as percentages of positive answers. Regarding the usability module (GQ1 to GQ9), the mean of "yes" answers were 35.4 (SD 4.0) and 19.1 (SD 2.4) for users and experts, respectively. Some experts ($N = 3$) reported that the game menu was difficult to find because they considered the use of an icon button not intuitive.

We also received detailed explanations for the questions where the answer was not so positive in order to get information for future app improvements. This information is not only useful for future improvements in our app, but also for other similar behav-

ior change apps and, more specifically, to those that directly target smoking cessation.

For those questions related to mobility, the number of "yes" answers to the question "I feel comfortable playing anywhere" (GQ11) and "no" answers to the question "It does not bother me not to be able to pause the game" is smaller (GQ12), $N = 27$ and $N = 15$, respectively. Regarding this, experts expressed that BBG and PEG were games which couldn't be used everywhere, and that games should have the option to be paused to answer phone calls or other situations.

Considering questions related to gameplay heuristics, only 18 users and 5 experts answer "yes" to the question "I feel that the game adapts to the improvement of my abilities" (GQ15). Most of users ($N = 28$) and experts ($N = 20$) considered the games to be repetitive and somewhat boring (GQ17). Some of experts ($N = 3$) considered the games to be too simple and they highlighted the lack of difficulty selection options.

Regarding the expert specific questions, experts expressed some concerns over the games in general or related to specific games (Appendix G). For the question "The games are visually pleasing" (EGQ1), although some told us that the colors used in CCG and BBG games were pleasant, most considered the games as not visually appealing, and with few animations ($N = 13,14,16$ for CCG, BBG and PEG respectively). The question "The player cannot make irreversible mistakes" (EGQ2) was answered positively by 21 experts and they reported the score is not recorded in the application when you finish playing and the result of these game plays did not have any repercussion in the app. For the question "The player has
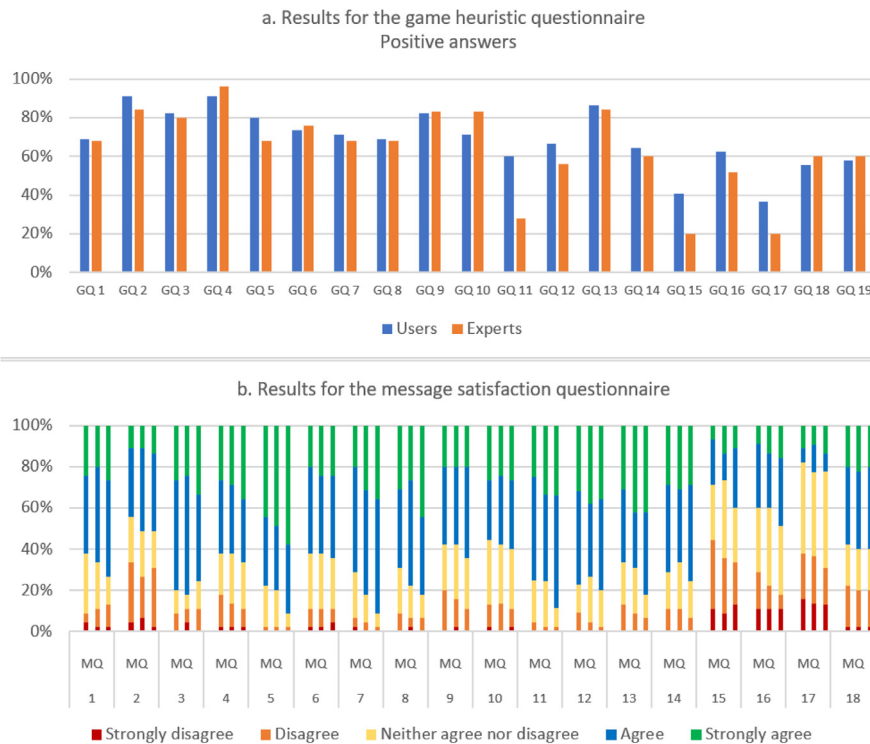
Fig. 3. Results for the questionnaires. Both charts show the percentage of users (and experts, only in 3a.) over the total users ($N = 45$ for valid users and $N = 25$ for experts).

control over the game" (EGQ3), most of the experts exposed the difficulties they faced to be able to use the game or to perform certain exercises. The last question, "The player can express himself in the game" (EGQ4) had very few positive opinions ($N = 3$ for both CCG and BBG and $N = 4$ for PEG).

3.2.2. Usage statistics

Fig. 4b shows the number of times the games were played as registered by the server during the three weeks of the study. In the first week the games have been widely used, but from the second week the use decreased notably, and it was reduced further during the third week. The BBG was the most played game, followed by CCG. Additionally, regarding these two games, results showed that the percentage of games that lasted more over a minute increased after the first week. Since these two games were one-minute long, this indicated that the number of completed games increased from the second week.

3.3. Message content satisfaction

The message satisfaction results are presented in Figs. 3b, 4c. For the first week, more than 60% of the answers for 11 out of 18 questions was 'agree' or 'strongly agree', and this rate increased in the last two weeks. The questions, "The messages recommended by the application were new" (MQ2), "The messages convinced me how to get social support from other people during the process of quitting" (MQ15) and "The messages helped me to prepare actions to pass through a difficult situation" (MQ17) presented the highest rates of disagreement (over 30%), with little variation during the three weeks (17.0 ± 2.6, 15.7 ± 1.5, respectively). Regarding the data collected from the application more than 68% of the message ratings (602/880) had four stars or more, and less than 20% (108/880) were rated with one or two stars.

3.4. App behavior analysis

Accesses to the remaining sections of the app are included in Fig. 4a. These accesses were considerably fewer in the second and third week. The achievements section was the most frequently accessed, with an average of 3 uses per day in the first week, and a daily access during the second and third week. The message tray was the next most used section, with 2 accesses per day in the first week, and less than one daily access for the remaining weeks. Most visits did not last more than 15 s for these sections, with mean duration values between 5 and 7 s for the message tray and profile sections, and between 4 and 5 s for the achievements section.

3.5. Expert reports

$N = 15$ experts (60%) contributed with additional comments. These reports were analyzed, extracting the most frequent topics (Appendix H). Regarding games, the most frequently positive comments were the ease of understanding of the game dynamics ($N = 4$) and the fact that games did not get stuck ($N = 3$). Some experts considered that games were boring ($N = 4$), too simple ($N = 3$), and with no option to pause them as the main negative issues ($N = 3$). It was considered that the games didn't help the users to avoid smoking ($N = 3$). There were suggestions to improve the audiovisual features ($N = 2$), to register the points won, to improve the engagement by modifying the game dynamics ($N = 4$), and to add auxiliary options such as game pause ($N = 3$) and difficulty selection ($N = 2$).

Regarding the application, the main positive comments mentioned were that the achievements section had a motivational influence ($N = 7$), the message tray section was understandable ($N = 6$), and the application was simple ($N = 6$) and easy to use ($N = 4$). The negative aspects were varied, and experts didn't agree much on them. The most common remark considered the games
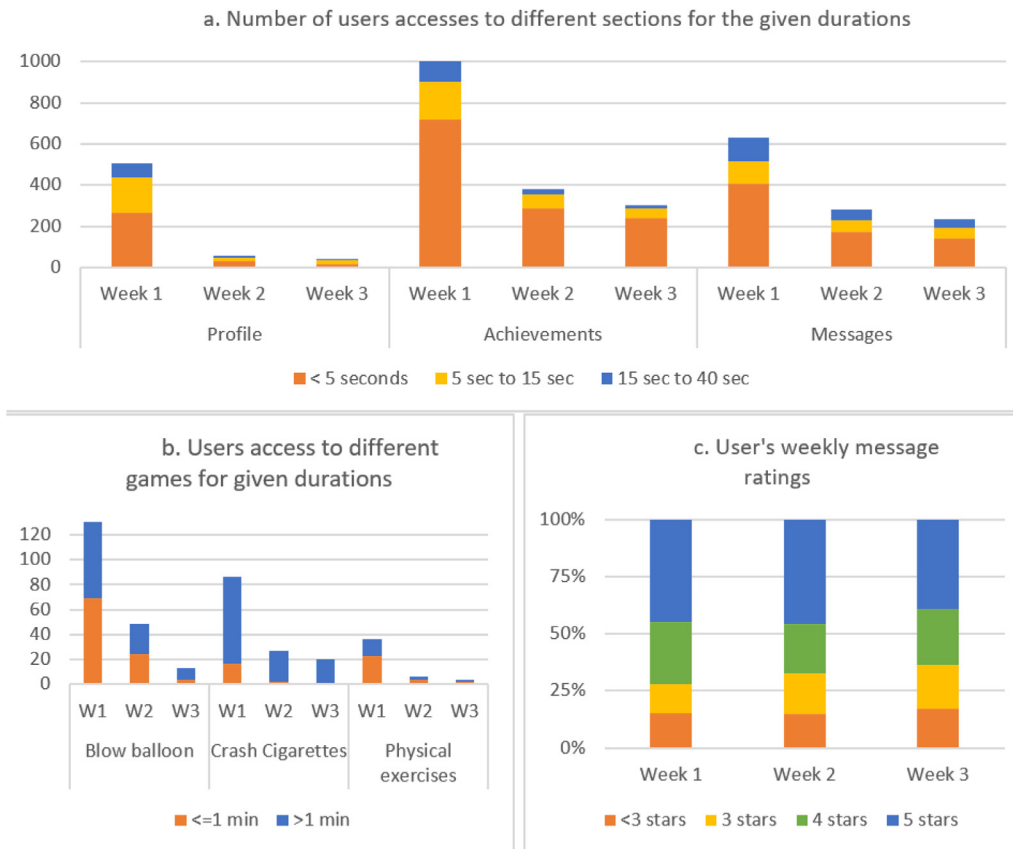
Fig. 4. Statistics extracted from server database.

difficult to find in the app because the game menu access button was not intuitive ($N = 3$). There were also some problems in receiving the messages in specific devices ($N = 3$).

4. Discussion

4.1. Principal findings

Questionnaires results and expert reports revealed that the games features presented good usability. On the other hand, some issues that affect the playability and mobility were detected. In our app, the repetitive dynamics, lack of difficulty level selection and pause option were the main problems mentioned for their modification or implementation. Some of these characteristics together with the improvement of audiovisual features make these games more attractive for the users, according to [35]. Although BBG was considered novel and entertaining, it was difficult to control on some smartphone models. This is due to varied technical specifications and the difficulties to recognize blowing in different environments [36]. CCG had the highest degree of retention. This fact reinforces the results obtained in [28] from which the game was designed. It is very important to consider that the games do not aim to engage the user, as is the case with common mobile games, but they are only a distraction to resist tobacco cravings [28]. Therefore, the addition of features that increase the engagement to the games but not to the application itself may not support the users during their quitting attempts. Games must be kept simple, but they should also be attractive enough to be able to distract the user during the craving [37]. Thus, adding extra features, as suggested by several experts, may not be a good idea and is a topic that requires further study.

The responses to the questionnaires as well as the usage records showed a high degree of satisfaction with the motivational messages. Several users considered that the message information was not new and did not provide advice on finding social support or facing craving moments. This may be related to the short time established for the study, as a large part of the users have not received messages dealing with this topic. This is a well-known issue called cold start problem [38] that usually affects recommender systems.

The most used sections were achievements and message tray. However, the number of accesses decayed in the second week. This could well be a consequence of a decreasing user adherence [39], probably since recruited users were not required to be willing to quit smoking. Most experts considered the app easy to use and understandable, but they pointed out that it was difficult to find how to access the game menu.

Overall, the set of methods used for this study revealed important information about usability, content satisfaction and usefulness. Health-related behavioral interventions through smartphones are increasingly popular, including smoking cessation [40] However, the use of recommender systems to tailor the messages in m-health is recent and there are few specific studies about them [41,42]. The method used in this study to assess the perceived value complements the analysis of efficiency by identifying influential factors. Games may provide a valuable aid in behavior change interventions, and specifically in smoking cessation [43]. Therefore, researches with their own implementation ns are emerging [5,44]. The heuristics set can assess the usability and playability of this kind of games. Thus, the applied methodology, are adequate to analyze the usability and satisfaction of mHealth apps to support smoking cessation programs, with different questionnaires depending on the implemented functionalities.

4.2. Limitations

The data from 21 users was discarded due to technical problems that were perceived by the lack of recorded data and by reports provided by the experts. Part of these cases may be due to compatibility problems with the mobile devices used. During the implementation, the application was tested for compatibility with several official versions of Android, starting with Android 4.4 Kit Kat as this is the first version that supports the required notifications. The high number of unofficial Android versions makes it difficult to create applications that are compatible with all existing devices. In addition, it should be noted that the installation of the application was made without the use of Google Play which manages the compatibility of applications with different devices. Most of users with similar profiles did receive messages, which indicates that the problem is not related to any user characteristic but lies mainly in the communication and reception of messages. During the implementation, some tests showed that the reception of messages could be blocked if the application was stopped by the mobile operating system to reduce power consumption. The Android power management varies according to the OS version and mainly the additional software provided by the device manufacturer. To prevent the application from being turned off, the users had to configure their device, and this task is different depending on the device. This clearly indicates the need to provide guidance in this topic at least for the most common devices.

Although the results of the questionnaires indicated, in some cases, that the games have been blocked, the comments of the experts saying the opposite suggested that the question on the questionnaire had been misinterpreted because it should have been formulated in a clearer way.

Regarding the motivational messages, some users indicated that the received messages contained similar information. This issue is related to the implemented recommendation system, which initially considers only the user's profile data when it does not yet have enough message rating information, in order to solve the cold start problem. Therefore, in the initial weeks some users can receive similar messages if the subject fits the user profile. The users will receive more varied contents better adapted to their preferences as they rate previous messages.

The application was designed for users who really wanted to quit smoking. The perceived value and application adherence are factors that may have been reduced considering that, in the study sample, users' motivation to quit smoking, among other smoking related variables, is very varied. This is clearly related to the participants selection approach.

5. Conclusions

The games in the app have a good usability. The game menu should be easier to find and clearly indicate its aim to the users. The expert reports revealed issues that explained the results obtained in questionnaires and that can be used to improve this application and others with similar objectives.

The messages have a good acceptance, but currently can be unreliable in some devices due to technical reasons related to their system configuration. To solve this, it could be necessary to provide the users with a guide regarding the necessary changes to their system configuration.

Although the use of the application has been moderate, the cohort of analyzed users does not present a great interest in quitting. Thus, better results are expected for the project's target audience.

This study presents a methodology that can be employed to assess health related mobile applications with similar functionalities, specifically in the context of smoke cessation programs. We consider that the methodology has demonstrated to be good enough to discover issues, which can be used to improve user's perceived value and satisfaction and the general application usability, given the quality and quantity of findings in this small study.

Appendix A. Procedure to establish a correct session in the study

Table A1
Steps provided to establish a correct session in the app.

0. Install the application	**Download the apk file provided in the device and install it.**
1. Create a user	Follow the steps indicated in the app to register it in the system.
2. Fill the profile forms	Fill the following forms:
	- Demographic form containing nickname, gender, date of birth and date of smoking initiation.
	- Addiction level (Fagerstrom test).
	- Motivation level (Richmond test).
	- Smoker habits form containing weekly tobacco expenditure (quantity and currency) and daily smoked cigarettes.
3. Establish a quitting attempt date	Select the option "Quit Smoking Now!" and set the date of beginning.

Appendix B. Message Satisfaction questionnaire provided to participants

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Satisfaction questionnaire for users about the messages of the mobile application in SmokeFreeBrain.

Please select one of the following 5 options for each statement. Please, respond with total **sincerity**, the questionnaire is **anonymous**, and **voluntary**. The ethical committee of the virgen del Rocío de Sevilla (Spain) has approved this questionnaire on July 12, 2017 with code: SFB-APP_EC-2016-01.
Please, the questions that you think do not apply to your situation, select the option:
 "Neither in agreement or in disagreement".

1. "The messages that the application recommended to me fit my interests"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

2. "The messages recommended by the application were novel"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

3. "The messages that the application recommended to me were diverse "

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

4. "The appearance of the message tray was adequate"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

5. "It was easy to tell the system if I liked the messages or not"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

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(*continued*)

6. "I felt in control of modifying my profile of interests"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

7. "I became familiar with the messaging system very quickly "

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

8. "I understood why they recommended me the messages they sent me "

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

9. "The messages gave me good suggestions"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

10. "In general, I am satisfied with the messages"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

11. "I can trust the messages "

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

12. "The messages convinced me that I was at risk of health problems if I went back to smoking"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

13. "The messages convinced me that smoking was a dangerous habit"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

(*continued*)

14. "The messages convinced me of the benefits of quitting "

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

15. "The messages convinced me about how to get social support from other people during the process of quitting "

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

16. "The messages helped me to feel confident that I could successfully quit tobacco"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

17. "The messages helped me prepare actions to cope with difficult situations"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

18. "I would recommend to friends who smoke to use the recommendations of the messages"

Totally disagree	disagreement	Neither in agreement nor in disagreement	Agree	Totally agree

Appendix C. Game questionnaire provided to participants

Mini-games usability questionnaire for users of the mobile application in SmokeFreeBrain

Please select "yes" or "no" for each statement.
Please, respond with total **sincerity**, the questionnaire is **anonymous**, and **voluntary**.

1. Sound and images support me in the game

Yes	No

2. The information shown is appropriate

Yes	No

3. I can see clearly the information that is shown during the game

Yes	No

4. The terminology used is understandable

Yes	No

5. I can access games quickly and intuitively

Yes	No

6. It was easy for me to adapt to the way I handled the game

Yes	No

7. The game correctly informs me of my actions

Yes	No

8. The instructions of each game do not contain unnecessary information

Yes	No

9. The instructions of each game are useful to understand the dynamics of the game

Yes	No

10. I do not waste a long time or perform many previous actions to start playing

Yes	No

11. I feel comfortable playing anywhere

Yes	No

12. It does not bother me not to be able to pause the game

Yes	No

13. The game provides clear objectives

Yes	No

14. The way the results are shown helps me to know my progress

Yes	No

15. I feel that the game adapts to the improvement of my abilities

Yes	No

16. My first experience encouraged me to continue playing

Yes	No

17. The game is repetitive and boring

Yes	No

18. The game doesn't get stuck

Yes	No

19. The response of the game is always what would be expected

Yes	No

Mini-games usability questionnaire for experts of the mobile application in SmokeFreeBrain

Experts should answer all the questions above and the following. They must give a critical answer about them
1. The games are visually pleasing
2. The player cannot make irreversible mistakes

Appendix D. Methodology used to filter data registered in the database

We set two thresholds to eliminate atypical values. With regards to main sections, the analysis of the frequency of accesses showed there were not a Gaussian distribution in data recovered (Fig. D1). The analysis of access with higher durations showed the most of accesses had a duration up to 40 s (Fig. D2). Based on this analysis, the lower threshold was set in 50 milliseconds and the higher threshold was set in 40 s.

Regarding to game plays, a gaussian distribution was perceived in CCG and BBG with values close to 65 s in the range between 60 s and 70 s (Figs. D3, D4). However, if consider all game plays registered, there were several game plays with a duration lower than 5.5 s and between 70 s and 80 s, especially with BBG. There was no normal distribution associated to PEG game plays. This game can last several minutes depending of the user. Considering the results, the lower threshold was set in 50 milliseconds and the higher threshold was set in 80 s for CCG and BBG games plays. We did not consider threshold for PEG.

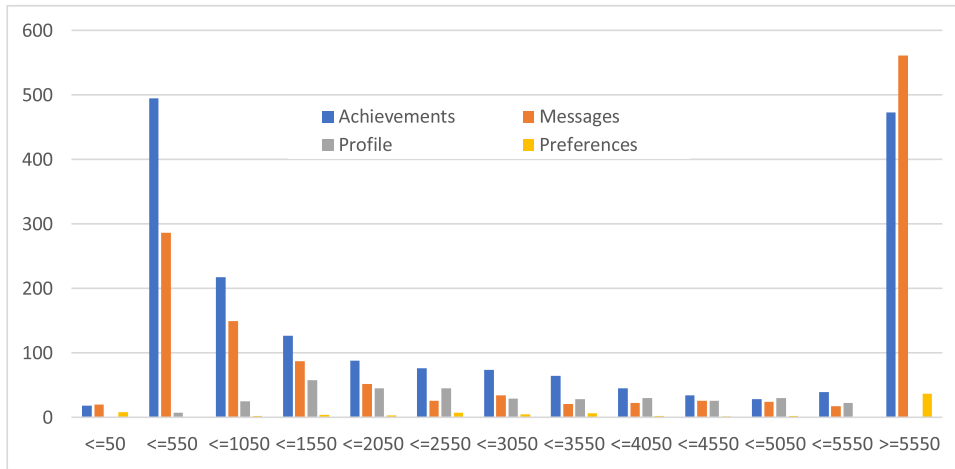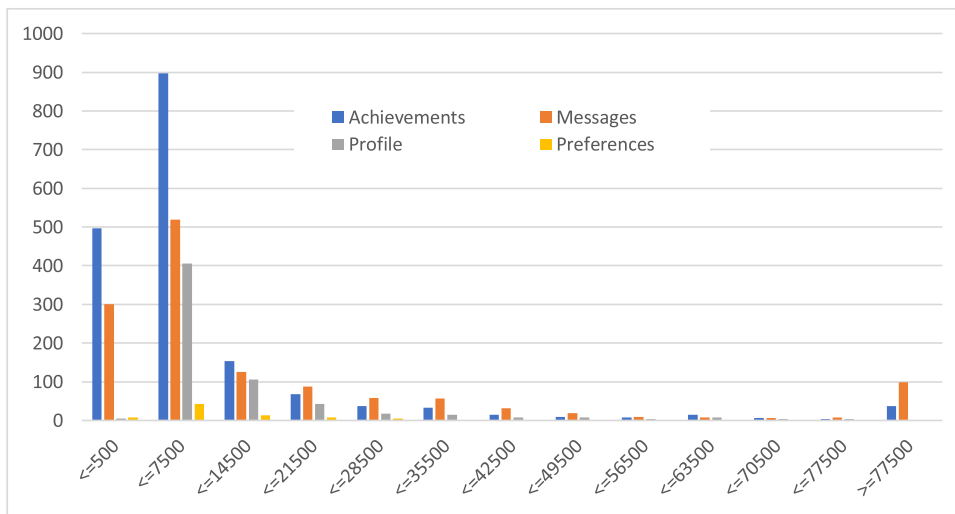**Fig. D1.** Distribution of main section accesses with duration interval of 500 milliseconds.

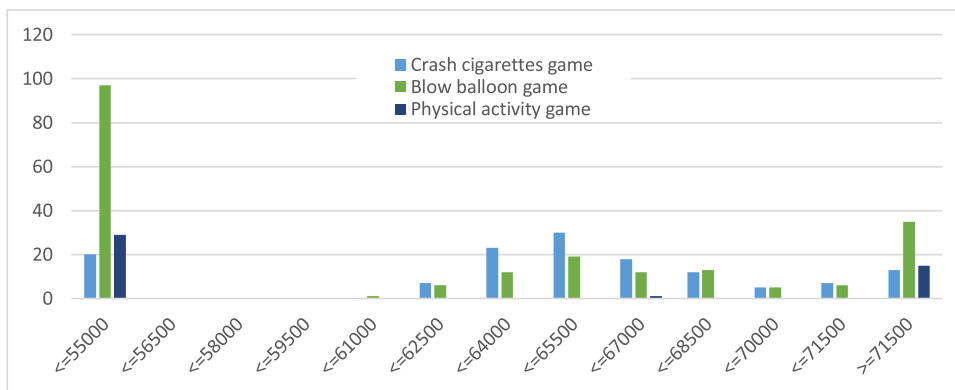**Fig. D2.** Distribution of main section accesses with duration interval of 7 s.

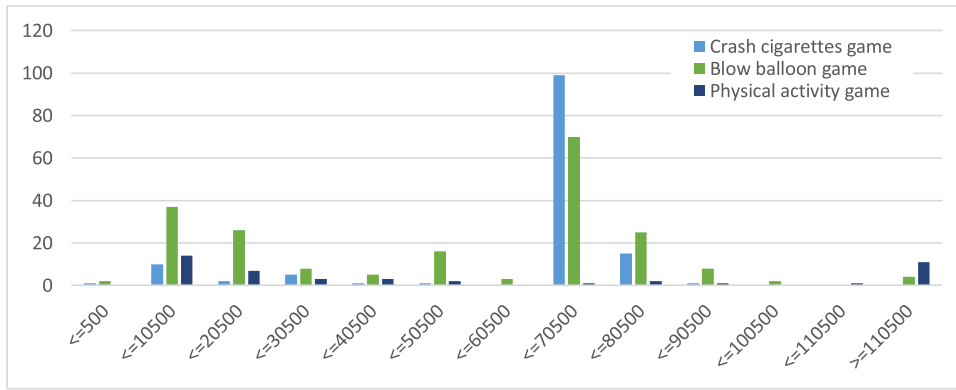**Fig. D3.** Distribution of game plays with a duration interval of 1.5 s.

Fig. D4. Distribution of game plays with a duration interval of 10 s.

Appendix E. Game questionnaire encoding

Table E1
Questionnaire based on playability heuristics for mobile games.

Question	Heuristic associated in [16]	
GQ 1	GU1	Sound and images support me in the game
GQ 2	GU3	The information shown is appropriate
GQ 3	GU4	I can see clearly the information that is shown during the game
GQ 4	GU5	The terminology used is understandable
GQ 5	GU6	I can access games quickly and intuitively
GQ 6	GU8	It was easy for me to adapt to the way I handled the game
GQ 7	GU9	The game correctly informs me of my actions
GQ 8	GU11	The instructions of each game do not contain unnecessary information
GQ 9	GU12	The instructions of each game are useful to understand the dynamics of the game
GQ 10	MO1	I do not waste a long time or perform many previous actions to start playing
GQ 11	MO2	I feel comfortable playing anywhere
GQ 12	MO3	It does not bother me not to be able to pause the game
GQ 13	GP1	The game provides clear objectives
GQ 14	GP2	The way the results are shown helps me to know my progress
GQ 15	GP5	I feel that the game adapts to the improvement of my abilities
GQ 16	GP6	My first experience encouraged me to continue playing
GQ 17	GP8	The game is repetitive and boring
GQ 18	GP11	The game doesn't get stuck
GQ 19	GP12	The response of the game is always what would be expected
EGQ 1	GU2	The games are visually pleasing
EGQ 2	GU10	The player cannot make irreversible mistakes
EGQ 3	GP4	The player has control over the game
EGQ 4	GP9	The player can express himself in the game

Appendix F. Message satisfaction questionnaire encoding

Table F1
Satisfaction questionnaire about the messages.

Question	
MQ 1	The messages recommended by the application fit my interests
MQ 2	The messages recommended by the application were new
MQ 3	The messages recommended by the application were diverse
MQ 4	The appearance of the message box was adequate
MQ 5	It was easy to tell the system if I liked the messages or not
MQ 6	I felt able to modify my profile of interests
MQ 7	I became familiar with the messaging system very quickly
MQ 8	I understood why they recommended me the messages they sent
MQ 9	The messages gave me good suggestions
MQ 10	In general, I am satisfied with the messages
MQ 11	I can trust the messages
MQ 12	The messages convinced me that I was at risk of health problems if I smoke again
MQ 13	The messages convinced me that smoking was a dangerous habit
MQ 14	The messages convinced me of the benefits of quitting
MQ 15	The messages convinced me how to get social support from other people during the process of quitting
MQ 16	The messages helped me to feel confident that I could successfully quit tobacco
MQ 17	The messages helped me prepare actions to pass through a difficult situation
MQ 18	I would recommend to friends who smoke to use the recommendations of the messages

Appendix G. Experts opinions

Table G1
Opinions from experts for the questions on games.

Question (heuristic)			Yes, n (%)	Main positive reasons	Main negative reasons
EGQ1	GU2	The games are visually pleasing		*The colors used in both crashing cigarettes and blow balloon games are visually pleasing	*Lack of animations makes the games unattractive *Game about physical exercise have low quality and very dark images
Blow balloon			12 (48,00)		
Crash cigarettes			11 (44,00)		
Physical activity			9 (36,00)		
EGQ2	GU10	The player cannot make irreversible mistakes		*The results of a game are neither stored in the app and this doesn't affect in the future	*If the player makes an error during the game, it is irreversible * It is not possible to go back to a previous exercise in the physical activity game
Blow balloon			21 (84,00)		
Crash cigarettes			22 (88,00)		
Physical activity			21 (84,00)		
EGQ3	GP4	The player has control over the game		*The player can see the punctuation and time during the game *The player can choice if start or skip each exercise in the physical activity	*It isn't possible to stop the Crash Cigarettes and Blow Balloon games *The Blow Balloon game doesn't seem to work appropriately depending of the mobile phone *In the crash cigarettes game, the cigarettes disappear too fast in the last seconds *Some physical exercises need tools to be carried out *The physical exercises can't retry individually. *The physical activity game doesn't indicate how many exercises are left
Blow balloon			10 (40,00)		
Crash cigarettes			13 (52,00)		
Physical activity			12 (48,00)		
EGQ4	GP9	The player can express himself in the game		*The physical activity game allows body expression *The player can think on different methods to solve the games	*The games have linear mechanics and they do not give the player the option to express themselves
Blow balloon			3 (12,00)		
Crash cigarettes			3 (12,00)		
Physical activity			4 (16,00)		

Appendix H

Table H1
Experts' critical opinions.

Opinion about the app			
Positive	N	Negative	N
The rewards section is motivational	7	The access to the games is hidden	3
The message section understandable	6	There are message receiving problems	3
The interface is simple	6		
The application is easy to use	4		
Opinion about the games			
Positive	N	Negative	N
The games are understandable	4	The games are boring	4
The application doesn't get stuck	3	Don't get to support during quitting attempt	3
		The games are very simple	3
Opinion about the messages			
Positive	N	Negative	N
The information is motivating	5	The information isn't motivating	4
The information is varied	3	The information isn't attractive	3

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