Psychiatry Research 272 (2019) 171–181

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Cognitive bias modification in problem and pathological gambling using a web-based approach-avoidance task: A pilot trial

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ARTICLE INFO

Keywords:
Approach-avoidance task
Cognitive bias modification
Internet
Problem gambling
Pathological gambling
Slot machine

ABSTRACT

There is evidence that training addicted participants to implicitly avoid disorder-related stimuli by using a training version of the Approach-Avoidance Task (AAT) results in reduced substance consumption (i.e., Approach Bias Modification [AppBM]). The aim of the present web-based study was to investigate the feasibility and effectiveness of AppBM in reducing gambling-related symptoms. A self-selected sample of participants with problem/pathological slot-machine gambling completed an online survey and received either AppBM or Sham training (final $N = 131$). Attrition during study participation was high (66%). In both conditions slot-machine related and neutral pictures were presented. Within the AppBM condition all slot-machine related pictures had to be pushed and all neutral pictures had to be pulled, whereas in the Sham condition the contingency was 50:50. Eight weeks after baseline, participants were re-assessed. Both groups showed a similar reduction in gambling-related symptoms. Findings are at odds with the hypothesis claiming that only contingency trainings yield beneficial effects. However, it cannot be ruled out that effects result from other factors unrelated to training such as expectancy effects. We think this study holds valuable information how to conduct larger trials in the future and may prove helpful to improve training and its delivery.

1. Introduction

In the DSM-5 (American Psychiatric Association [APA], 2013) pathological gambling is no longer classified as an impulse control disorder, but as a behavioral addiction and named “gambling disorder”; however, this classification is subject to an ongoing discussion (e.g., Hand, 1998; 2010). One striking feature of pathological gambling is that the behavior is remained even in view of often severe negative consequences. This discrepancy has been reconciled with dual-process theories which postulate that thinking and behavior are driven by two types of information processing (Deutsch and Strack, 2006; Evans and Coventry, 2006). According to these dual-process theories, one type of processing is fast, associative and operates outside of conscious awareness (*associative system*) while the second type is slow, logical and consciously accessible (*reflective system*). It is assumed that *automatic* processes of information processing play a central role in the formation and maintenance of gambling behavior. However, the original dual-process theory has been criticized for their ambiguous empirical evidence (Keren and Schul, 2009). Based on neurobiological findings, advancements of dual-process theories such as the Iterative Reprocessing Model (Cunningham et al., 2007) and the Reinforcement/Reprocessing Model of Reflectivity (R^3, Gladwin et al., 2011) have been proposed. The latter theoretical accounts assume that the temporal dynamics of information processing are crucial as early evaluations can be re-interpreted with continued processing, which involves a shift to more reflective processing. In this view, evaluative processes are the result of a complex interplay between automatic and strategic processes. Notwithstanding their criticism, the original dual-process theories hold a strong heuristic value for the explanation of the “addiction paradox” and the assumption that *automatic* information processing is biased in problematic and pathological gambling[1] has been confirmed in numerous studies: gambling has been associated with attentional biases (Ciccarelli et al., 2016a, 2016b; Hønsi et al., 2013; Hudson et al., 2016; Vizcaino et al., 2013) and these biases seem to be specific to the preferred gambling activity (McGrath et al., 2018). Additionally, implicit memory biases between gambling-related stimuli and positive

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[1] Problem gambling refers to the subclinical form of the DSM diagnosis pathological gambling.

https://doi.org/10.1016/j.psychres.2018.12.075
Received 4 March 2018; Received in revised form 13 December 2018; Accepted 14 December 2018
Available online 14 December 2018

attributes (Brevers et al., 2013) as well as positive outcome expectancies have been reported (Stewart et al., 2015; Stiles et al., 2016). In the latter two studies, implicit (positive) outcome expectancies predicted unique variance in the amount of time and money spent on gambling. Additionally, more severe symptoms were correlated with more positive implicit outcome expectancies.

These patterns of information processing resemble those of substance-related addictive disorders. Apart from attentional biases (Field and Cox, 2008) substance-related addictive disorders are also associated with an implicit behavioral tendency to approach disorder-related stimuli (Cousijn et al., 2011; Machulska et al., 2015; Wiers et al., 2009). These implicit behavioral tendencies can be assessed by means of arm movements, for example, with the Approach-Avoidance Task (AAT, Rinck and Becker, 2007). The AAT builds upon the finding that approach is associated with faster arm flexion than extension and avoidance with faster arm extension than flexion (Marsh et al., 2005). In order to measure behavioral tendencies implicitly, an indirect instruction is used such that the direction of movement (i.e., pull versus push) depends on a non-affective dimension (Rinck and Becker, 2007). A recent study provides first evidence that moderate-to-high-risk gambling is also associated with an approach bias for gambling-related stimuli (Boffo et al., 2018). It was found that non-treatment seeking moderate-to-high-risk gamblers showed a stronger approach bias for gambling-related compared to neutral stimuli, whereas no differences emerged in non-problem gamblers. Furthermore, a stronger approach bias at baseline predicted maintenance of monthly frequency and total duration of gambling six months later.

Given their central role for the maintenance of different problem behaviors, trainings that aim to modify the automatic processes of information processing, mostly termed Cognitive Bias Modification (CBM) procedures, have been developed. In order to specifically modify implicit behavioral approach tendencies, Approach Bias Modification (AppBM) has been introduced for specific psychopathologies. To this end, disorder-related and neutral stimuli are presented to participants and the instruction is to push disorder-relevant stimuli away and to pull neutral stimuli closer. Thereby, the implicit bias to approach disorder-related stimuli should be attenuated, which, in turn, should result in a reduction of the primary problem behavior (Wiers et al., 2011). Several studies have revealed that abstinence rates could be increased by means of AppBM procedures in both abstinent alcoholic inpatients (Eberl et al., 2013; Rinck et al., 2018; Wiers et al., 2011) and patients undergoing alcohol detoxification (Manning et al., 2016). In a sample of inpatient psychiatric smokers there was a significantly stronger reduction of daily cigarette consumption three months after the intervention when a low-threshold smoking cessation intervention was combined with AppBM compared to Sham training (Machulska et al., 2016). AppBM has also been administered as a web-based device: one study with a self-selected sample of smokers showed that participants receiving the AppBM training showed a significantly larger reduction of cigarette consumption and tobacco dependence compared to the WLC at post-test (Wittekind et al., 2015). In a similar vein, Wiers et al. (2015) recruited a sample of self-selected problem drinkers who were allocated to one of five conditions (three different AppBM trainings, one attention and one Sham training). Irrespective of condition, all participants significantly reduced their alcohol consumption across time.

In summary, while there is some evidence that AppBM training increases abstinence rates and decreases different problem behaviors in patient samples, evidence regarding the effectiveness of web-based AppBM trainings is promising, but less solid.

The present study

The present study was part of a larger trial aiming at investigating the effectiveness of two different computer-based trainings in problem and pathological gambling (for the other study arm see Bücker et al., 2018). A web-based approach was chosen as only a very small proportion of problem and pathological gamblers eventually seek treatment or attends Gamblers Anonymous (e.g., Cunningham, 2005; Slutske, 2006) and there are encouraging findings using web-based interventions (Chebli and Gainsbury, 2016). Thus, low threshold and anonymous treatment options might provide the possibility to reach those that would otherwise be reluctant to seek formal help and provide a foot-in-the-door approach. The aim of the present pilot trial was to investigate whether training problem gamblers to avoid gambling-related stimuli leads to a reduction of gambling-related symptoms. As the variety of games in problem gambling is large (e.g., roulette, card games, slot machines), we limited our study to slot-machine gambling as the prevalence of problem and pathological gambling is particularly high among this subgroup (Institut für interdisziplinäre Sucht- und Drogenforschung, 2015; Kessler et al., 2008). Our primary aim of the present study was to test the feasibility (i.e., enrolment, online recruitment, compliance) and effectiveness of web-based AppBM training in gambling. Due to the online set-up and the software used, we were not able to assess implicit behavioral tendencies before and after the training We accepted this limitation although we are aware that results are more substantial if one can show that CBM trainings change the bias in the intended direction (e.g., MacLeod and Clarke, 2015). We hypothesized that AppBM training would result in a greater reduction of the overall severity of gambling symptoms (Yale Brown Obsessive Compulsive Scale adapted for Pathological Gambling [PG-YBOCS], primary outcome) compared to Sham training. We further assumed that this reduction was mainly driven by a reduction of the behavioral subscale of the PG-YBOCS (secondary outcome). Additionally, we investigated whether there was a dose-response relationship between frequency of use and training effects. We assumed that more days of training would be associated with better outcome.

2. Materials and methods

2.1. Recruitment

Recruitment took place in Germany between May 2014 and June 2016. Participants were recruited online via gambling- and addiction-related internet forums, websites on problem and pathological gambling, social networks (e.g., Facebook) and a campaign on Google AdWords (if keywords like “gambling-addiction” or “slot-machine addicted” were searched, interested parties were led to a webpage of our working group on which all information relevant for the study was presented). A description of the study in written form and a link were provided that directed participants to the first page of an online survey (see 2.3). Additionally, flyers describing the aims and the procedure of the study were sent to self-help groups, counseling centers, inpatient and outpatient treatment facilities for gambling and were laid out in gambling halls across Germany. Furthermore, several advertisements were run in different newspapers. Via the study link, the online survey could be accessed, starting with the introduction page on which the rationale and the procedure were explained in more detail and participants were asked to give informed consent before the main survey started. The procedure was approved by the Ethics committee of the German Psychological Society (reference number: SM_012014_2).

2.2. Participants and inclusion and exclusion criteria

As the aim of the present study was to evaluate the feasibility and effectiveness of two different online trainings in gambling, we sought individuals with problem or pathological gambling on slot-machines. To recruit individuals looking for help, the recruitment strategies described above were applied. As this was the first study that investigated AppBM training in gambling and because we were interested whether the training exerts any positive effects on symptoms, varying levels of severity were included. Interested parties could participate in the study if they reported a total score of ≥ 1 in the South Oaks Gambling Screen (SOGS, Lesieur and Blume, 1987), subjective feelings of sadness and desperation, were between 18 and 65 years old and had sufficient knowledge of the German language. Feelings of sadness and desperation was applied as an inclusion criteria because different online trainings were evaluated within the larger project and the other study arm applied a training for depressive symptoms (Bücker et al., 2018). This inclusion criterion was provided to participants in the description of the study and it was explicitly mentioned as an inclusion criterion ("*You can participate in the study if you often feel depressed, desperate, or sad*"); however, inclusion was based on self-evaluation and no cut-off for symptom severity was applied. Consequently, it is likely that all kinds of problem gamblers participated (i.e., also "behavioral conditioned gamblers" only mildly suffering from comorbid psychopathologies) and not just those who use gambling as a coping strategy (i.e., "emotionally vulnerable gambler", Blaszczynski and Nower, 2002). Acute suicidal tendencies, a lifetime diagnosis of a bipolar/manic or psychotic disorder, and indicating that questions had not been answered honestly led to study exclusion. Inclusion and exclusion criteria were requested during the survey (self-report). In case criteria were violated, participants were automatically re-directed to a page on which the reasons for exclusion were explained and an emergency number was provided. Cookies prevented that persons who had been excluded were able to participate a second time.

2.3. Pre-assessment

The study was fully web-based and set up using questback® (www.unipark.com/de). The survey started with detailed information about the rationale and the procedure of the study. Subsequently, an online informed consent was inquired and in case it was given, the survey proceeded. The survey consisted of the following sections: assessment of demographic (e.g., gender, age, level of education) and clinical information (e.g., current treatment due to mental problems, psychiatric/psychological disorders, application of self-help techniques), administration of several questionnaires (see 2.7), inquiry whether questions were answered honestly, request to provide an email address for the post-assessment and an anonymous code.

2.4. Group allocation

This study was part of a larger project pursuing the following goals: (1) assessment of characteristics of problem and pathological gamblers (cross-sectional), (2) investigation of the feasibility and effectiveness of two different online trainings in problem/pathological gambling. Originally, the study had been planned with four groups, thus, participants were directly randomized to one of the four groups (i.e., Deprexis, AppBM, Sham, WLC) with a 1:1:1:1 allocation ratio upon completion of the baseline assessment. As the two online trainings pursue different goals and have a different theoretical background (Deprexis is a web-based treatment targeting depressive symptoms and was administered to reduce depressive symptoms in the present study; AppBM training aims to modify implicit approach biases towards gambling-related stimuli and was administered to reduce gambling-related symptoms), the four-arm study was split into two separate studies with a parallel design (data of the other treatment arm are reported in Bücker et al., 2018). The randomization sequence was generated by the first author using the program www.randomizer.org and participants were randomized by the second author. As participation was self-selected and there was no personal contact to participants, allocation is different from standard clinical trials with personal assessment in which team members perform enrolment. Thus, as there is no risk of bias, treatment allocation was not concealed. After the pre-assessment participants were sent an email including a pdf document containing a description of the AppBM or Sham training (see Supplementary Material 2), an instruction on how to download and use the training and a link to download either AppBM or Sham training. Both groups were given the same rationale of the study and differences between trainings were not explicitly explained to participants in order to maintain blinding. No monetary reimbursement was offered for study participation; however, participants could download self-help intervention manuals at the end of the post-assessment (e.g., mindfulness).

2.5. Training

Both trainings were programmed using *Visual Basic 2010 Express* (Microsoft©) by Ansgar Feist (AF) and can be used for Windows XP and all newer versions. The training procedures had to be downloaded and installed by participants. The app ran directly on their local computer, consequently, we did not have access to any of the data (i.e., training data, urge ratings, frequency of training). In total, ten pictures related to slot-machine gambling and 10 neutral pictures were used. Pictures related to slot-machine gambling were searched via the internet and neutral pictures were either selected from the International Affective Picture System (IAPS; Lang et al., 1997) or the internet.[2]

When the program was started, a blue screen appeared with three different buttons in the left upright corner (instruction button, button to start the training, button to quit the training). After pressing the start button, a slot-machine related picture was depicted and it was inquired how big the urge to gamble was at that moment using a visual analogue scale (0 [no urge at all] to 100 [very strong urge]). Subsequently, the training started and slot-machine related and neutral pictures were presented in fully random order. Depending on a non-affective dimension (color of the picture frame, either blue or yellow), pictures had to be pushed (i.e., avoidance) or pulled (i.e., approach) with the computer mouse. To initiate a trial, participants had to click a button ("Please click here") that was located at the center of the screen. Then, a fixation cross was presented (500 ms) to focus participants´ attention to the center of the screen, followed by either a slot-machine related or neutral picture (see Fig. 2). To increase the visual impression of approach and avoidance, pictures grew smaller during the push- and larger during the pull-movement (Rinck and Becker, 2007). If the mouse[3] was moved in the right direction, the picture finally disappeared. If the mouse was moved in the wrong direction, an error message occurred indicating that the mouse had to be moved in the other direction. After disappearance of the picture, the central button had to be pressed and the next trial was initiated. During each trial, the cursor was invisible. In total, each participant performed 200 trials. At the end of the training, participants were again asked to indicate their current urge to gamble. The two urge ratings were included to provide participants with feedback about their change in urge. Finally, participants were provided a short feedback (mean reaction time for pushing and pulling, change of urge to gamble). In the AppBM condition, all slot-machine related pictures were framed in the color that was associated with pushing, whereas all neutral pictures were framed in the color associated with pulling. In the Sham training condition, 50% of the slot-machine related and 50% of the neutral pictures had to be pushed, and 50% of each picture type had to be pulled. Thus, the only difference between the two conditions was the contingency.

2.6. Post-assessment

Eight weeks after baseline, participants were sent an email and invited to participate in the post-assessment. Again, a link was provided directing participants to the assessment. Firstly, the email address and the code were inquired. Subsequently, the following information was

[2] Stimulus selection is described in the supplementary material (S1).

[3] In order to make the time taken to complete the movement comparable between the joystick and the mouse version, the mouse speed was reduced automatically by the program and the mouse acceleration was turned off.

assessed: questionnaires of the baseline assessment (except sociodemographic and clinical information), subjective evaluation of the training (including the inquiry on how many days the training was used), assessment of treatment (psychological treatment [yes/no], current or past application of self-help techniques [yes/no; if participants indicated that they applied self-help techniques, it was inquired which techniques was used], current medication [yes/no; in case medication was taken, the name of the drug was inquired]), whether all questions had been answered honestly (yes/no). After completion of the post-assessment participants were thanked for their participation and could download manuals on progressive muscle relaxation and mindfulness.

2.7. Questionnaires

2.7.1. Primary outcome

The severity of gambling symptoms served as primary outcome and was assessed using the Yale Brown Obsessive Compulsive Scale adapted for Pathological Gambling (PG-YBOCS, DeCaria et al., 1998; German translation: Cremer et al., 2001). Our primary outcome deviates from previous studies which used the problem behavior as the main outcome (Machulska et al., 2016; Wiers et al., 2015); however, we consider gambling behavior as *one aspect* of the symptom spectrum besides other highly relevant symptoms (e.g., urge to gamble, impairment in daily life). Therefore, we considered the total score of the PG-YBOCS a clinically more relevant outcome (in a prior web-based study we also assessed symptom severity, see Wittekind et al., 2015). Severity of symptoms within the last week is inquired by means of ten items (five items assess urges and thoughts associated with gambling, five items assess behavioral gambling-related activities). Internal consistency (Cronbach´s α) is excellent (total scale α = 0.97; subscale thoughts/urges: α = 0.94; subscale behavior: α = 0.934) (Pallanti et al., 2005). Due to the online set-up of the study, the scale was administered as a self-report questionnaire. Internal consistency for the PG-YBOCS (at baseline, N = 131) is good (Cronbach´s α = 0.854).

2.7.2. Secondary outcomes

The subscales *thoughts/urges* and *behavior* of the PG-YBOCS, impulsivity (assessed with the Eysenck Impulsiveness Questionnaire, subscale Impulsivity [Eysenck et al., 1985]) as well as depressive symptoms (assessed with the Patient Health Questionnaire – 9-item Depression Module [PHQ-9; Kroenke et al., 2001]) served as secondary outcomes. Impulsivity was assessed with the 17-item subscale Impulsivity of the Eysenck Impulsiveness Questionnaire, which consists of the subscales impulsiveness, venturesomeness, and empathy. Reliability of the subscale is good (α = 0.82 - 0.85 [Eysenck et al., 1985; Eysenck and Eysenck, 1978]). The PHQ-9 is a self-report measure that enables to establish a depressive disorder diagnosis as well as the assessment of symptom severity. Internal consistency can be considered excellent (Cronbach´s α = 0.86 - 0.89). In the present study, internal consistencies can be considered satisfactory to good for the subscales of the PG-YBOCS (subscale thoughts: Cronbach´s α = 0.706; subscale behavior: Cronbach´s α = 0.776) and the PHQ-9 (Cronbach´s α = 0.826). Internal consistency of the subscale impulsivity was unsatisfactory, however (Cronbach´s α = 0.506).[4]

[4] The study was part of a larger project. Thus, in addition to the questionnaires reported in this article, other questionnaires were also administered at baseline (Generalized Anxiety Disorder Scale-7 [GAD-7], several items of the Gambling Attitudes and Beliefs Scale [GABS], assessment of different cognitive biases, Short Questionnaire on Gambling Behavior [KFG; Kurzfragebogen zum Glücksspielverhalten]; however, these measures were relevant for the parent trial and thus not considered for the present study.

2.7.3. Screening questionnaires

To screen for pathological gambling, the South Oaks Gambling Screen (SOGS, Lesieur and Blume, 1987) was administered. To screen for the most common mental disorders, the Web Screening Questionnaire (WSQ, Donker et al., 2009) was applied. Sensitivity ranges between 0.72–1.00, whereas specificity ranges from 0.44–0.77.

2.8. Subjective evaluation of trainings

At the post-assessment, participants were asked several questions pertaining to the trainings (see Table 4). Furthermore, participants were asked whether they used the mouse or a touchpad to conduct the trainings, on how many days the training was conducted, what they (dis-)liked about the training and what should be improved, whether they would use the training in the future, whether the training fulfilled their expectations and lastly whether the training changed the participants´ motivation to use other therapeutic approaches (see Table 4).

2.9. Strategy of data analysis

Data were analysed using the IBM *Statistical Package for Social Sciences* (SPSS, version 24) and R Language for Statistical Computing (R Core Team, 2018). Participants who indicated that they did not answer the questions honestly (n = 2), withdrew informed consent (n = 2), did not suffer from slot-machine related gambling problems (n = 5), or were strongly suicidal according to the WSQ (n = 1) were excluded from analyses after randomization (see Fig. 1). To assess baseline differences, independent t-tests were used for continuous variables and chi-square tests for categorical data. To test the main hypothesis, linear mixed effects models (MEM, lme4 package in R, Bates et al., 2015) were applied. The lme4 package uses unstructured variance-covariance matrices for the random effects. This approach was mainly chosen over repeated-measure analyses of variances (ANOVA) as it is possible to pool results across all imputed datasets. A time * group interaction term was included. Due to the pre-post design, the model incorporated time as random slope and the participant ID as random intercept. No correlation between random intercept and slope was assumed. As groups did not differ on demographic and psychopathological variables at baseline (see Table 1), we refrained from entering these variables as covariates to the model.[5] All analyses regarding secondary outcomes were also conducted using MEM with a time * group interaction term and random participant intercepts. Regression estimates, 95% confidence intervals (CI), and significance tests (α was set at 0.05 for all statistical tests) are summarized in Table 3. In order to investigate a possible dose-response relationship and whether impulsivity was related to training effects, correlations for the variables number of days the training was used, impulsivity, and pre-post-differences (total score PG-YBOCS, subscales PG-YBOCS, PHQ-9) were calculated in the per protocol sample.

Modified intention-to-treat (ITT) and per protocol (PP) analyses were performed. For modified ITT, data of all participants who were randomized and met inclusion criteria were used. Ten participants that had been randomized were excluded for modified ITT analyses (see Fig. 1). Missing data at the post-assessment were assumed to be missing at random and imputed with multivariate imputation by chained equations (MICE), using the mice package (Van Buuren and Groothuis-Oudshoorn, 2011). As it has been suggested in the literature that the number of imputations should be proportioned to the percentage of missing data (Graham et al., 2007), we ran 40 imputations. Subsequently, scores for all assessment scales were computed for each of the 40 imputed data sets, which were then pooled to one single score/questionnaire (see Table 2). This approach was chosen as it is recommended

[5] For the modified intention-to-treat sample, groups differed as to severity of depressive symptoms at baseline. We repeated all analyses with depression as a covariate; however, the pattern of results remained unchanged.

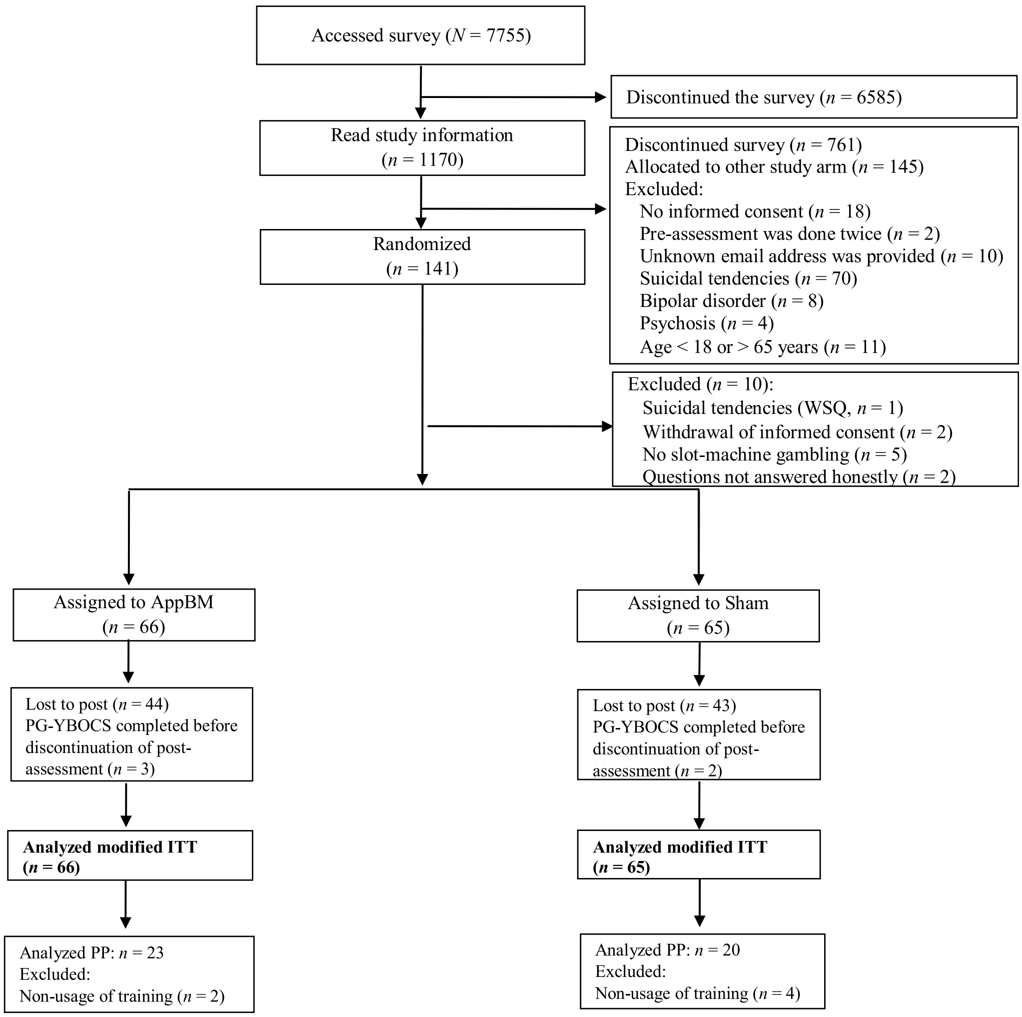

Fig. 1. Flow of participants. Ten participants were excluded after randomization, leaving 131 participants for analyses.

to first run the analyses on each imputed (complete) dataset and to pool coefficients afterwards, including standard errors, when using MICE (Azur et al., 2011). The same procedure was applied for the linear MEMs: analyses were run for each imputed datasets, then, results were pooled. For PP analyses, all participants were considered who completed both assessments and indicated that they used the training at least once. For the PP sample, pre-post effect sizes (Cohen´s *d*) were calculated for each dependent variable for each group with $d \approx 0.2$ indicating a small, $d \approx 0.5$ a medium, and $d \approx 0.8$ a large effect (Cohen, 1988). Due to the low power of the PP group, we computed the Bayes Factor to compare different models, using the brms package (Bürkner, 2017). For each outcome, three models were calculated (one model with "Time" as predictor, one with "Time" and "Group" as predictors and the final model with the interaction term between "Time" * "Group"). The Bayes Factor suggests if a model performs better after adding certain predictors or interaction terms. Furthermore, Bayesian tests for practical equivalence (Kruschke, 2018) were performed on the same models for the PP analyses. Bayes Factor and tests for practical equivalence are presented in the Supplementary Material 3. In addition, clinically significant change was computed in the PP sample using the clinsig package (Lemon, 2016).

3. Results

3.1. Pre-assessment

Demographic and psychopathological information of the modified ITT- as well as the PP samples are presented in Table 1. Within the PP-sample, groups did not differ significantly in any of the variables, all *ps* > 0.05. In the modified ITT-sample, groups only differed regarding severity of depressive symptoms, $p = 0.006$ (see Table 1). Only a minority of participants sought help for mental health problems.

3.2. Completion rate

As can be derived from Fig. 1, 65% of participants who started the baseline assessment did not finish it. Of the 141 participants who were ultimately randomized, ten participants were later excluded (see Fig. 1) leaving a final sample of 131 participants. Of the final sample, 44 participants completed the post-assessment (34%). Three participants of the AppBM group and two participants of the Sham group started the post-assessment and completed the PG-YBOCS before dropping out, thus, their data were included for PP analyses. Additionally, two participants of the AppBM group and four participants of the Sham group indicated that they did not use the program and were excluded from PP analyses leaving 23 participants in the AppBM and 20 participants in the Sham group for PP analyses.

Completion rate did not differ between groups (AppBM: 33% [$n = 22$], Sham: 34% [$n = 22$]), $\chi(1) < 1$, $p = 0.950$). Non-completers and completers did not differ as to education (years of school), gender, nationality, psychiatric disorders, or any of the questionnaire scores at baseline, all *ps* > 0.2. However, completers were older than non-completers (completers: $M = 38.68$, $SD = 12.18$; non-completers: $M = 33.41$, $SD = 9.94$, $t(72.71) = 2.48$, $p = 0.015$) and applied more self-help interventions (completers: 6 out of 44 [14%], non-completers:

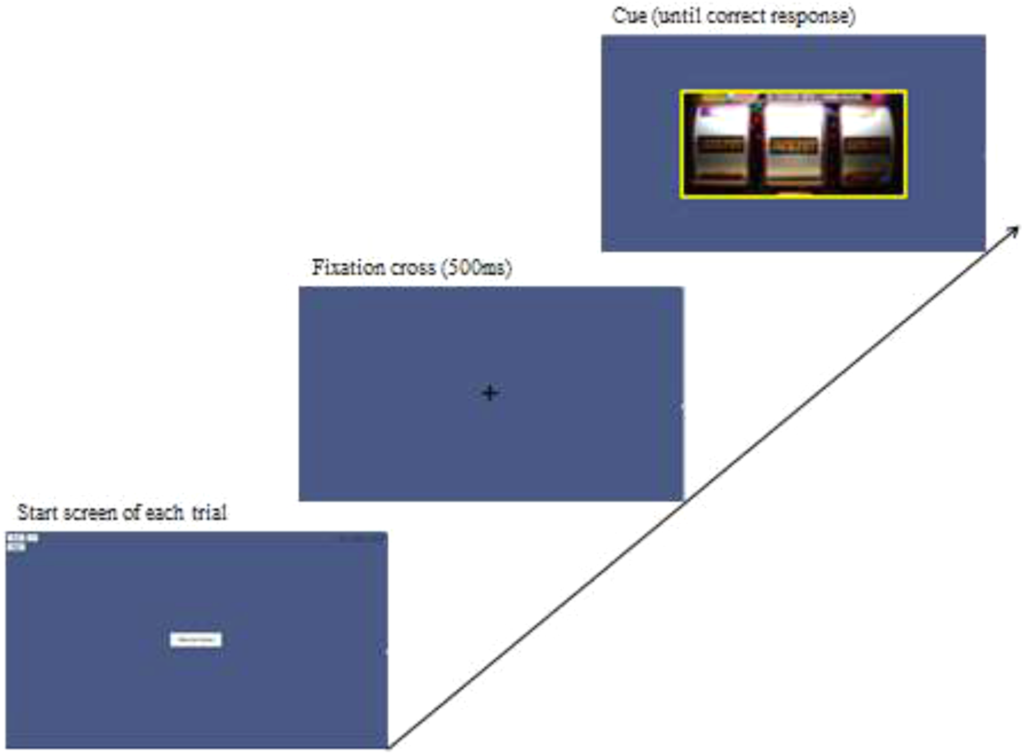

Fig. 2. Example of a training trial. To initiate the trial, participants had to click the button in the center of the screen. In the left upright corner, participants saw different buttons (Start, Exit, "?") and in the right upright corner the number of the respective trial. After pressing the button, a fixation cross was presented ms = and then a neutral or gambling-related picture was presented until the mouse was moved in the correct direction.

Table 1
Sociodemographic and psychopathological information for both the modified ITT- and the PP-sample: means (SD) and frequencies.

Variable/time	ITT AppBM (n = 66)	Sham (n = 65)	Statistics	PP AppBM (n = 23)	Sham (n = 20)	Statistics
Age (in years)	36.62 (10.32)	33.72 (11.53)	t(129) = 1.52, p = 0.132	39.61 (11.98)	38.35 (12.70)	t(41) < 1, p = 0.740
Education (years of school)	10.80 (1.42)[a]	10.84 (1.55)	t(128) < 1, p = 0.860	10.96 (1.46)	10.85 (1.73)	t(41) < 1, p = 0.828
Gender (m/f)	52/14	46/19	χ(1) = 1.12, p = 0.290	18/5	16/4	χ(1) < 1, p = 0.889
SOGS	10.02 (3.27)	10.32 (3.31)	t(129) < 1, p = 0.593	10.61 (3.24)	10.10 (3.09)	t(41) < 1, p = 0.603
PG-YBOCS total	17.83 (2.30)	19.63 (6.15)	t(129) = 1.52, p = 0.130	20.13 (7.47)	18.95 (5.06)	t(41) < 1, p = 0.554
PG-YBOCS thoughts/urges	8.98 (3.88)	9.91 (3.07)	t(129) = 1.51, p = 0.134	10.22 (4.33)	9.10 (2.59)	t(36.68) = 1.04, p = 0.304
PG-YBOCS behavior	8.85 (3.75)	9.72 (3.68)	t(129) = 1.35, p = 0.180	9.91 (3.53)	9.85 (2.93)	t(41) < 1, p = 0.950
PHQ-9	10.29 (5.18)	12.74 (4.87)	t(129) = 2.79, p = 0.006	11.96 (6.04)	12.60 (5.33)	t(41) < 1, p = 0.715
Impulsivity	9.14 (4.16)	10.23 (3.77)	t(129) = 1.58, p = 0.117	9.61 (3.75)	10.90 (3.82)	t(41) = 1.12, p = 0271
Psychiatric disorders (yes /no)[b]	57/9	60/5	χ(1) = 1.21, p = 0.271	20/3	19/1	χ(1) < 1, p = 0.365
Depression (yes/no)	15/51	19/46		8/15	6/14	
GAD (yes/no)	25/41	29/36		13/10	8/12	
PD (yes/no)	21/45	25/40		9/14	7/13	
PD w Ago (yes/no)	7/59	5/60		3/20	4/16	
Ago (yes/no)	11/55	9/56		5/18	6/14	
SP (yes/no)	28/38	29/36		8/15	9/11	
Soc Phobia (yes/no)	23/43	31/34		12/11	9/11	
PTSD (yes/no)	30/36	36/29		8/15	14/6	
OCD (yes/no)	23/43	35/30		7/16	11/9	
AD (yes/no)	8/58	8/57		3/20	4/16	
Psychological treatment due to mental problems (yes/no)	10/56	14/51	χ(1) < 1, p = 0.345	3/20	6/14	χ(1) = 1.86, p = 0.173
Nationality (German/Other)	62/4	56/9	χ(1) = 2.22, p = 0.136	23/0	18/2	χ(1) = 2.41, p = 0.120
Application of SH (no/yes)	63/3	59/6	χ(1) = 1.12, p = 0.289	20/3	17/3	χ(1) < 1, p = 0.853

Note. AppBM = Approach-Bias Modification; SOGS = South Oaks Gambling Screen; PG-YBOCS = Pathological Gambling Yale-Brown Obsessive Compulsive Scale (0–7 = subclinical, 8–15 = moderate; 16–23 = average, 24–31 = severe, 32–40 = extreme); PHQ-9 = Patient Health Questionnaire – 9 items (0–4 = minimal, 5–9 = mild, 10–14 =
moderate, 15–27 = severe); GAD = Generalized Anxiety Disorder; PD = Panic Disorder; w = with; Ago = Agoraphobia; SP = Specific Phobia; Soc = Social; PTSD = Posttraumatic
Stress Disorder; OCD = Obsessive Compulsive Disorder; SH = Self-help;

[a] n = 65;

[b] as assessed with the WSQ. Number across all disorders.

Table 2
Questionnaire scores of the post-assessment for both the modified intention-to-treat- and the per-protocol-samples: means (SD).

Variable/time	Modified ITT (MI, m = 40)		PP	
	AppBM (n = 66)	Sham (n = 65)	AppBM (n = 23)	Sham (n = 20)
PG-YBOCS total	12.95 (6.45)	13.38 (5.94)	12.35 (8.46)	11.85 (7.03)
PG-YBOCS thoughts/urge	7.05 (3.48)	7.26 (3.08)	6.74 (4.17)	6.50 (3.14)
PG-YBOCS behavior	5.90 (3.45)	6.12 (3.38)	5.61 (4.52)	5.35 (4.12)
PHQ-9	9.70 (5.18)	10.44 (4.97)	8.91 (6.69)	9.25 (5.98)

Note. AppBM = Approach-Bias Modification; MI = Multiple Imputation
PG-YBOCS = Pathological Gambling Yale-Brown Obsessive Compulsive Scale;
PHQ-9 = Patient Health Questionnaire – 9 items

3 out of 87 [4%], $\chi(1) = 4.74$, $p = 0.029$).

3.3. Per protocol analyses

Results of scores at the post-assessment are depicted in Table 2, results of the linear MEMs in Table 3.[6] Regarding the primary outcome (total score PG-YBOCS), there was a significant reduction in overall symptom severity from pre- to post-assessment with large effects in both groups (AppBM: $d = -1.00$, 95% CI [−1.60 – −0.34], Sham: $d = -1.20$, 95% CI [−1.90 – −0.45]). Contrary to hypothesis, no differences between groups across time emerged. This pattern emerged for all secondary outcomes as well: a significant reduction emerged for the subscales of the PG-YBOCS (thoughts: AppBM: $d = -0.84$, 95% CI [−1.50 – −0.20], Sham: $d = -0.93$, 95% CI [−1.60 – −0.23]; behavior: AppBM: $d = -1.10$, 95% CI [−1.70 – −0.42], Sham: $d = -1.30$, 95% CI [−2.00 – −0.54]) and severity of depressive symptoms (AppBM: $d = -0.51$, 95% CI [−1.10 – 0.10], Sham: $d = -0.61$, 95% CI [−1.20 – 0.05]). The Bayes Factor derived from the Bayesian models confirmed that the model improved most when the interaction term Group * Time was used as a predictor compared to the usage of either “Time” or “Time” and “Group” as predictors. Additionally, tests for practical equivalence revealed strong evidence for an effect of time, whereas no firm conclusions regarding the interaction Group * Time can be drawn (see Supplementary Material 3). Consequently, based on our data, the H0 can neither be accepted nor rejected.

Regarding reliable change, analyses revealed that approximately half of the participants of each group did not improve reliably (AppBM: 12 out of 23 [52%]; Sham: 9 out of 20 [45%]), one quarter improved reliably (AppBM: 6 out of 23 [26%]; Sham: 4 out of 20 [20%]) while one fifth of the AppBM (AppBM: 5 out of 23 [22%]) and one third of the Sham group showed clinically significant change (Sham: 6 out of 20 [30%], see Supplementary Material 5).

3.4. Modified intention-to-treat analysis

Despite the large number of missing values, results could mostly be replicated using multiple imputation (MI, see Table 3). There was a statistically significant reduction across time in symptom severity of gambling-related problems in both groups. However, none of the reductions was significantly more pronounced in the AppBM- compared to the Sham group. There was no improvement as to the severity of depressive symptoms in the modified ITT analysis.

3.5. Subjective appraisal and usage of the training

In Table 4, subjective appraisal and usage of the training for both groups are summarized. Generally, the majority of both groups considered the training suitable for self-administration, the description of the program comprehensible, the training helpful and indicated that they managed to use the training regularly (although participants also indicated that they had to push themselves to do so). On the other hand, participants stated that they considered the training not applicable for their gambling-related problems. One third of the AppBM- and half of the Sham group would use the training in the future. Days of usage (self-report) did not differ significantly between groups.

3.6. Correlations

Number of days the training was used was not related to stronger symptom reduction: PG-YBOCS total score, $r_{34} = -0.026$, $p = 0.885$; PG-YBOCS subscale thoughts/urge, $r_{34} = -0.165$, $p = 0.352$; PG-YBOCS subscale behavior, $r_{34} = 0.104$, $p = 0.557$; PHQ-9, $r = -0.190$, $p = 0.282$. Impulsivity at baseline was not associated with a stronger reduction of gambling-related symptoms: PG-YBOCS total: $r_{43} = 0.196$, $p = 0.207$; PG-YBOCS thoughts/urges: $r_{43} = 0.216$, $p = 0.163$; PG-YBOCS behavior: $r_{43} = 0.153$, $p = 0.327$; PHQ-9, $r_{43} = 0.158$, $p = 0.325$.

4. Discussion

The aim of the present pilot trial was to test whether web-based AppBM training would be feasible and effective in reducing gambling-related symptoms. To meet this aim, individuals with problem or pathological gambling related to slot machines were recruited online and randomized to either AppBM or Sham training upon completion of a pre-assessment.

4.1. Summary of main results

Both groups showed a similar, but significant reduction on the primary outcome (severity of gambling-related symptoms [total score PG-YBOCS]) from pre- to post-assessment in both the PP- and modified ITT-analyses. Reductions were large in the PP sample and not related to the number of days the training was used and impulsivity. Almost half of the participants in both groups showed reliable or clinically significant change. Significant reductions across time also emerged for both subscales, that is, gambling-related thoughts as well as behaviors. For depressive symptoms, a significant medium-sized reduction was found in the PP-, but not in the modified ITT-analyses. Although our hypotheses that AppBM training would be more effective than the control condition were not supported, training effects were large in both groups and comparable to the effects obtained in CBT meta-analyses (−1.82, Cowlishaw et al., 2012; −0.72, Gooding and Tarrier, 2009). This is noteworthy given that AppBM trainings are low-threshold and less intense.

Our results resemble findings of an earlier web-based study in a sample of self-selected problem drinkers in which the same pattern of results emerged, that is, all conditions (i.e., active and Sham) significantly reduced alcohol consumption (Wiers et al., 2015). In contrast, in the study of Wittekind et al. (2015) only participants receiving

[6] As a score of ≥ 8 is suggested as a SOGS cut-off score for pathological gambling (Goodie et al., 2013), a sensitivity analyses was conducted including all participants with a SOGS score ≥ 8 (results of both the modified ITT and PP analyses remained unchanged and data are provided in the Supplementary Material 4).

Table 3
Results of the linear mixed effects model for all dependent variables, PP- and modified ITT-sample.

Fixed parts	PG-YBOCS total (primary endpoint)			PG-YBOCS thoughts/urges (secondary endpoint)			PG-YBOCS Behavior (secondary endpoint)			PHQ-9 (secondary endpoint)		
	B	*CI*[a]	*p*	*B*	*CI*	*p*	*B*	*CI*	*p*	*B*	*CI*	*p*
PP												
Time	−7.78	−11.18 – −4.39	< 0.001	−4.30	−6.17 – −2.44	< 0.001	−3.48	−5.19 – −1.77	< 0.001	−3.24	−5.90 – −0.59	0.022
Group	−1.86	−9.45 – 5.72	0.633	0.13	−396 – 4.23	0.950	−2.00	−6.12 – 2.13	0.349	0.75	−5.40 – 6.91	0.812
Group * Time	0.68	−4.29 – 5.66	0.789	−0.20	−2.93 – 2.54	0.889	0.88	−1.63 – 3.38	0.469	−0.11	−3.93 – 3.71	0.956
Modified ITT												
Time	−4.88	−7.76 – −2.00	0.001	−1.93	−3.56 – −0.29	0.022	−2.95	−4.51 – −1.39	< 0.001	−0.59	−3.43 – 2.25	0.677
Group	3.17	−1.52 – 7.86	0.185	1.64	−0.83 – 4.12	0.192	1.53	−1–15 – 4.20	0.262	4.16	0.61 – 7.70	0.022
Group * Time	−1.37	−4.45 – 1.71	0.380	−0.72	−2.40 – 0.96	0.398	−0.65	−2.41 – 1.11	0.466	−1.70	−4.07 – 0.66	0.156

Note.
[a] 95% confidence interval. As a SOGS score of ≥ 8 is recommended as a cut-off for a diagnosis of pathological gambling (Goodie et al., 2013), analyses were re-run including all participants with a SOGS score ≥ 8; however, results remained unchanged (see Supplementary Material 4).

the AppBM training showed significant reductions of cigarette consumption and tobacco dependence compared to a WLC; however, as no Sham condition was included, comparability between studies is restricted. Results of the present study diverge from findings in clinical samples where AppBM trainings consistently outperformed the Sham training condition (Machulska et al., 2016; Manning et al., 2016; Wiers et al., 2011). Differences between studies might explain the inconsistent findings. One major difference between the present and studies with clinical samples is that symptom severity instead of abstinence or gambling behavior was used as the primary outcome, thus, it is possible that group differences can be found somewhere else (i.e., actual gambling behavior). Most studies so far observed positive effects on abstinence (Eberl et al., 2013; Manning et al., 2016; Wiers et al., 2011) or problem behavior (Machulska et al., 2016). However, in one previous study in smoking AppBM training also exerted positive effects on symptoms (Wittekind et al., 2015). Additionally, while AppBM trainings are administered as add-on trainings in clinical samples, they have been applied as stand-alone trainings in all web-based studies. As already argued by Wiers et al. (2015), it is possible that AppBM training only outperforms Sham training when blended with other treatments targeting the more controlled processes of information processing. Another major difference between clinical and web-based studies is the setting and regime of training. Participants conduct the training in the clinic in the former and at home without any personal contact in the latter studies. Furthermore, in all web-based studies (Wiers et al., 2015; Wittekind et al., 2015) a mouse instead of a joystick was used to conduct the training. Although a zoom function was incorporated in the mouse version such that pushing and pulling was clearly associated with approach (i.e., size increases) and avoidance (i.e., size increases) – comparable to the joystick training - direct comparisons between different training versions are needed to determine whether different training regimes (e.g., mouse, joystick, keyboard keys, tablets) are indeed comparable.

An explanation for the beneficial effects of both trainings might be that both trainings exert positive effects on other cognitive functions, for example executive functions, thereby increasing participants´ control over their gambling-related thoughts and behaviors. Corroborating evidence was found in studies using attentional bias modification (ABM), in which Sham trainings were as effective as ABM trainings in reducing symptoms, possibly because both trainings improved executive functions (Heeren et al., 2015; McNally et al., 2013). If the latter interpretation was true, this would be at odds with the assumed working mechanisms of CBM procedures (Koster et al., 2009). To systematically investigate the working mechanisms of CBM trainings, future studies should assess the target cognitive bias, but also other cognitive functions before and after the intervention.

Alternatively, changes might have been caused by factors unrelated to training. Possibly, cue exposure might have contributed to the effectiveness as participants were confronted with gambling-related stimuli without performing their problematic behavior. Furthermore, participants were given feedback on their changes in urge to gamble after the training, which could have affected gambling behavior and resulted in stronger self-monitoring. Consequently, the decrease in gambling symptoms might result from individual feedback in combination with exposure to gambling-related cues and be independent of training contingency. Furthermore, placebo- or expectancy effects could play a role as improvement might be attributed to positive expectations induced by participating in a study and conducting training. This would be in line with the well-known fact that some of the gamblers on a waiting list for CBT stop gambling right after their decision to go into treatment. Furthermore, changes might partially be explained by assessment reactivity as it has been shown that screening for and assessment of problem behavior (e.g., alcohol consumption) results in its reduction (e.g., McCambridge and Day, 2008; Walters et al., 2009). Future studies need to include a waitlist control group to control for these effects.

Table 4
Subjective evaluation of the trainings.

Item	AppBM ($n = 17$)	Sham ($n = 17$)	Statistics
The program is appropriate for self-administration.[a]	88%	72%	$\chi(1) = 1.40$, $p = 0.237$
My gambling-related problems were reduced by using the program.[a]	59%	59%	$\chi(1) = 0.00$, $p > 0.999$
The description of the program was written comprehensively. [a]	88%	94%	$\chi(1) < 1$, $p = 0.545$
The program was useful.[a]	82%	71%	$\chi(1) < 1$, $p = 0.419$
I managed to use the program regularly in the last weeks.[a]	82%	71%	$\chi(1) < 1$, $p = 0.419$
I had to push myself to use the program regularly.[a]	71%	71%	$\chi(1) = 0.00$, $p > 0.999$
The program is applicable as an adjunct to psychotherapy.[a]	65%	53%	$\chi(1) < 1$, $p = 0.486$
The program is not applicable for my gambling-related problems.[a]	77%	71%	$\chi(1) < 1$, $p = 0.697$
Will you use the program in the future?[b] (% yes)	35%	53%	$\chi(1) = 1.07$, $p = 0.300$
Days the training was used (self-report)	17.71 (19.87) Range: 1–60	14.47 (16.27) Range: 1–54	$t(32) < 1$, $p = 0.607$
Usage of mouse/touchpad to conduct training	16/1	14/3	$\chi(1) = 1.13$, $p = 0.287$

Note.
[a] Scale ranging from disagree, slightly agree, agree; percent are summed for "agree" and "slightly agree"
[b] yes, no;

Subjective evaluations of the trainings revealed that although the majority of participants of both groups considered the training suitable for self-administration and helpful, it was also stated that the training was not considered applicable to gambling-related problems. Additionally, only one third of the AppBM- and half of the Sham training group stated that they would use the training again. One can only speculate why this was the case. One limitation of CBM trainings is that they are rather monotonous and that participants might not consider the training helpful or related to their problems. A recent study showed that it is important to provide patients a rationale explaining how the trainings work (Vervaeke et al., 2018). Additionally, participants represented a relatively severe sample, thus, the training in isolation might not have been sufficient for participants. Given the severity of symptoms and the fact that AppBM trainings are mostly administered as add-on trainings, future web-based studies should combine CBT based interventions with AppBM training (e.g., van Deursen et al., 2013).

Regarding attrition, three different measures can be differentiated (Gooding and Tarrier, 2009). First, attrition from eligible sample: in the present study, 65% of participants who started the baseline assessment did not finish it. Second, attrition during study participation was also high (66%) and indicates "the difficulty of keeping participants engaged in research" (Gooding and Tarrier, 2009, p. 600). Third, attrition rate from active treatment, which cannot be determined in the present study as no access to the training data existed. The high attrition rate during study participation restrains interpretability of results. Given the small number of complete cases, low statistical power seems a probable explanation for the non-significant interaction.[7] However, as both groups show almost identical improvements with comparable effects, low statistical power as the sole explanation seems unlikely. Bayes statistics revealed that the evidence of group differences was inconclusive, thus, it remains to be tested whether the non-significant interaction effects represent a true null effect or result from low statistical power. Future studies with larger sample sizes are needed to answer the question whether AppBM training is more effective than Sham training in gambling. The attrition rate during study participation is comparable to a similar web-based study in problem drinking (Wiers et al., 2015). Additionally, several studies using technology-assisted self-help in other addictive disorders also reported attrition rates above 60% (for review see Newman et al., 2011), thus, drop-out in e-health interventions is the norm rather than exception. Interestingly and comparable to the results of Wiers et al., 65% of participants of the present study who started the baseline assessment did not finish it showing how difficult it is to recruit the target population. There are several reasons which could explain the high attrition rate in the present and other web-based studies: Some participants might have enrolled due to the low barrier entry, although they were not yet in the stage of actual change (stage of change model, Prochaska et al., 1992) or might have lost interest and motivation. There is tentative evidence indicating that the majority of patients drops out before interventions start (Melville et al., 2007), which could be indicative of low motivation or ambivalence. Confirming evidence is reported by Bücker et al. (2018) who found that 49% of participants randomized to the Deprexis arm never activated their voucher. In this case, compliance would need to be improved in a first step, for example, by assessing motivation right at the beginning and then applying motivational interventions tailored to the motivational stage of each participant. It is also conceivable that participants were bored by the trainings or did not perceive the training as helpful and dropped out for these reasons. Additionally, there was no therapeutic contact during the trial, which might have further decreased motivation. Future self-help and internet-based interventions might benefit from providing at least minimum therapist contact as it has been shown that the inclusion of minimal contact yielded better outcomes (Campos et al., 2016; Newman et al., 2011; Rash and Petry, 2014). As it is impossible to figure out which predictors for dropout apply, results have to be interpreted with caution as it is conceivable that the final sample might not be representative of the typical population.

4.2. Limitations

Results of the present study need to be interpreted against the background of several limitations. Due to the set-up of the study and the use of Visual Basic®, we were neither able to assess behavioral tendencies before and after the intervention nor any training data, which represents a clear limitation. Consequently, we cannot derive any conclusions regarding possible working mechanisms of the trainings, are not able to analyze participants´ performance during the training phase (i.e., we cannot derive any conclusions whether a change in urge might mediate the effect of the training on the outcome; individual differences as to reaction time and accuracy cannot be analysed), and cannot verify how often the training was conducted (i.e., we cannot track whether participants who did not complete the post-assessment used the training). As almost 50% of the other study arm did not use the intervention (Bücker et al., 2018) and participants of both studies are comparable, it is conceivable that this percentage would also emerge in the present study.

Methodological limitations include picture selection which was based on ratings regarding valence and personal relevance as well as arousal while participants did not evaluate the brightness and

[7] For linear mixed models, power calculation require a set of variables that need to be specified, amongst others a set of variance values. These can be estimated on the basis of prior data (Guo et al., 2013). As the current study is the first that investigated the effectiveness of ABM training in gambling, we did not have sufficient information to calculate the sample size for the analyses applied, which clearly represents a limitation of the present study.

complexity of the pictures. Furthermore, although the aim and procedure of the study was described in detail to participants, we remained rather vague when explaining the trainings in order to keep placebo and expectancy effects as low as possible. However, as a study revealed that providing a convincing rationale and psychoeducation is important to increase engagement (Vervaeke et al., 2018), it might have been better to explain the trainings and their aim in more detail. Furthermore, we cannot derive any conclusions how long lasting the obtained effects are as no follow-up assessment was included. Based on the findings of Machulska et al. (2016), it would have been interesting to assess whether the AppBM group would have shown further improvement. However, the aim of this randomized-controlled web-based pilot trial was to assess the feasibility, acceptance, and effectiveness of the training and as the attrition rate was already high at the post-assessment, probably there wouldn´t have been a sufficient number of participants at follow.

4.3. Implications

This was the first pilot trial that employed AppBM training to problem and pathological gambling. Despite the preliminary character of the study, we tried to follow CONSORT guidelines. Results revealed similar improvements in gambling-related symptoms across time in both groups. However, the high attrition rate indicates that acceptability was rather low and strongly constrains interpretability of results. Before firm conclusion regarding the effectiveness of AppBM trainings in problem and pathological gambling can be drawn, studies in large, clinical samples are needed. Additionally, as both groups improved from pre- to post-assessment, the working mechanisms of AppBM trainings and other explanations unrelated to training such as assessment reactivity need to be systematically investigated in future studies.

Ethical approval

"All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards."

"This article does not contain any studies with animals performed by any of the authors."

Informed consent

"Informed consent was obtained from all individual participants included in the study."

Conflict of interest

The study was funded by the Gauselmann AG, a German producer of slot machines. The funding company had no influence on the study design, implementation, data collection, data analyses, writing of the manuscript, or the decision to submit the paper for publication. In Germany, the gambling industry is legally obliged to spend money on the prevention and treatment of gambling-related problems (Glücksspielstaatsvertrag).

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2018.12.075.

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