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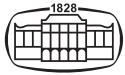
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# Computerized cognitive training for problem gambling: A randomized controlled trial (TRAIN-online)




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## FULL-LENGTH REPORT



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### ABSTRACT

**Background:** Non-face-to-face interventions offer promise, with cognitive training showing potential but inconsistent efficacy in problem gambling. **Methods:** We conducted a non-face-to-face, parallel, randomized, controlled, single-blinded trial to evaluate training programs in adults with problem gambling (CPGI  $\geq 5$ ). Participants were randomized 1:1 to a web-based cognitive training program targeting inhibition unrelated to addiction cues or a control program on visuo-spatial functioning. Both programs benefited from weekly phone calls to support engagement and transferability to daily life. A mixed community and out-patient sample was recruited at the national-level. The primary outcome was change in CPGI at week 6. Secondary outcomes were change in impulsivity, gambling behavior and quality of life at 6 and 14 weeks. **Results:** 187 participants were screened, with 185 randomized: 93 to intervention and 92 to control. No significant differences were found between groups for any outcome. Mean PGSI change at 6 weeks was  $-2.75$ , 95% CI  $[-12.95; 7.44]$  in the experimental arm versus  $-2.44$ , 95% CI  $[-13.52; 8.64]$  in controls,  $p = 0.76$ . 34% of participants were classed as no longer problem gamblers at week 14. Intervention acceptability was moderate, with 21 participants (22.58%) in the experimental group, and 32 (34.78%) controls never accessing the platform ( $p = 0.07$ ). **Conclusions:** Further research is needed to optimize cognitive interventions in problem gambling, to improve engagement and to demonstrate their added value beyond minimal intervention. For a number of problem gamblers, minimal telephone interventions appeared to be sufficient to reduce gambling. Objective account-based gambling data will provide valuable insights into long-term and objective effects.

### KEYWORDS

RCT, problem gambling, non face-to-face intervention, efficacy, cognitive training

## INTRODUCTION

The treatment gap is a challenge in gambling disorder (J. M. Costes, 2019), and the prevalence of gambling disorder is increasing in some countries, while the rate of at-risk and problem gamblers among gamblers increases globally (Abbott, 2020; J. Costes, Richard, Eroukmanoff, Le Nézet, & Philippon, 2020). Non-face-to-face interventions could be acceptable alternative sources of help (N. Boumparis et al., 2022; Gainsbury & Blaszczynski, 2011; Mide et al., 2023; Rodda et al., 2018). The most common internet-based interventions are online cognitive behavioral therapies (CBT), self-help content, and personalized normative feedback (N. Boumparis et al., 2022). Cognitive training is an operationalized type of cognitive

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remediation showing promise for relapse prevention in addictions based on the role of neurocognitive impairments in substance use disorders and behavioral addictions (Luquiens, Miranda, Benyamina, Carre, & Aubin, 2018; Verdejo-Garcia et al., 2023). Indeed, these approaches aim to be transferable to ecological situations, with application beyond experimental tasks in a real-life perspective. However, cognitive training is infrequently reported in programs in alcohol use disorder (Nixon & Lewis, 2019). Most studies report direct neuropsychological outcomes, while others have shown parallel improvements on other outcomes, i.e. well-being and craving (Anderson, Youssef, Robinson, Lubman, & Verdejo-Garcia, 2021). Interestingly, several studies have demonstrated the possibility of generalization of skills trained by cognitive rehabilitation programs, leading to pragmatic recommendations to focus on deficits related to relapse in substance use disorders (Maurage, Rolland, Pitel, & D'Hondt, 2024).

The content of assessed programs in addictive disorders is heterogeneous, and can target multiple executive functions frequently impaired, not associated with strong spontaneous recovery during early abstinence, or associated with relapse: inhibition, attention, working memory and visual-spatial skills (Maurage et al., 2024; Verdejo-Garcia et al., 2023). Programs can be divided into two categories: those training reactions to addiction-relevant cues; and those in which general abilities are trained independently of any addiction relevant cue (neutral and/or non-specific stimuli) (Wiers, Pan, van Dessel, Rinck, & Lindenmeyer, 2023). Despite the robust data documenting the inhibition deficit in addictive disorders, very few data are available on the efficacy of cognitive training tasks or programs targeting inhibition skills (Anderson et al., 2021). However, the therapeutic potential in addiction, including gambling disorder, of interventions that improve self-regulation skills has been repeatedly suggested (Kayser, Vega, Weinstein, Peters, & Mitchell, 2017; Shi & Li, 2023; Tang, Posner, Rothbart, & Volkow, 2015).

The most explored technique is cognitive bias modification, with disappointing results (Boffo et al., 2019), followed by cue-specific motor response inhibition (Jones et al., 2020). Control conditions training to respond to addiction-related cue could have artificially increased effect size in addiction-related cues inhibition training (Jones et al., 2020; Kilwein, Bernhardt, Stryker, & Looby, 2018; Schonberg et al., 2014). In addition, control conditions mixing go and no-go instructions for addiction-related cues could be confusing for participants as they are exposed to alcohol cues, which could increase craving and alcohol consumption (Field & Jones, 2017). These studies report mixed results (Di Lemma & Field, 2017; Jones et al., 2020). Moreover, the optimal control condition in control training groups has not yet been identified (Luquiens et al., 2018). Several studies reported similar improvements and no difference between inhibitory control training programs (participants trained to not respond to an addiction-related cue), and active control training programs (participants were inhibited from responding toward neutral stimuli) (Hughes et al., 2021), suggesting efficacy of training general abilities related to

non-specific stimuli. These results were supported by recent findings in patients with alcohol use disorder trained with non-specific demanding executive functions training (Finn et al., 2022). Overall, rigorous cognitive training enhances executive cognitive capacity across various domains, although the specific mechanisms driving these improvements remain unclear. The feasibility of transfer to daily life of benefits from cognitive training using unspecific exercises is still to be documented in addictions. In the context of addiction, inhibitory control is a critical process that could be effectively targeted in treatment and prevention efforts. In particular, impaired functions in gambling disorder reported in the literature are planning (Ledgerwood et al., 2012), decision making (Ledgerwood et al., 2012), delay discounting (Wölfling, Duven, Wejbera, Beutel, & Müller, 2020), reward process (Brevers, Koritzky, Bechara, & Noël, 2014), executive control and inhibition (Chowdhury, Livesey, Blaszczyński, & Harris, 2017; Luquiens et al., 2018). The most explored cognitive deficits in gambling disorder correspond to the cognitive facets of behavioral impulsivity. Behavioral impulsivity is classically divided into impulsive actions and impulsive choices (Grant & Chamberlain, 2014). The neurocognitive correlates of impulsive actions are motor disinhibition, and cognitive disinhibition, including interference management. The neurocognitive correlates of impulsive choices are delay-discounting and impulsive decision making. Inhibitory control is defined as the ability to suppress activated, but outdated or otherwise inappropriate representations or processes (Wessel & Anderson, 2023). Penolazzi et al. found contrasting patterns of inhibitory control deficits in gambling disorders compared to previously described patterns in substance use disorders (Penolazzi et al., 2020), suggesting that interventions focusing on motor and visuo-spatial inhibitory control may be beneficial for individuals with problem gambling.

In this study, we tested an alternative intervention based on cognitive training among problem gamblers, as described in a previous article (Santiago et al., 2021). We propose a web-based, randomized, controlled, single-blinded clinical trial, assessing the efficacy of a computerized cognitive training program targeting inhibition unrelated to addiction cues, in people with problem gambling, versus a control program on visual working memory. This method aimed at mitigate the issues of participant reactivity seen with cue exposure but also using a control program on visual working memory which provides a balanced comparison for efficacy without activating addiction-related responses.

## METHODS

### Study design and population

In this parallel, randomized, controlled, single-blinded trial, all problem gamblers contacting the research team via a dedicated email address were eligible for inclusion. Initially, the study was designed for non-treatment seeking problem gamblers screened by willing gambling service providers and



the national regulation authority, but policy changes meant that they only advertised the study on their websites. The study had broad media coverage through national newspapers, radio programs and gambling online forums. Due to difficulty in recruitment, aggravated by the COVID-19 crisis, the study was also offered to treatment seeking problem gamblers attending services affiliated to the national network for care and prevention in problem gambling (RNPSJP). We thus included a mixed community-based and out-patient sample. The recruitment period ran from 12th February 2019 to 8th March 2023.

Inclusion criteria were gamblers over 18 years old, with a Canadian Problem Gambling Index- Problem Gambling Severity Index (CPGI-PGSI)-recent  $\geq 5$  (recall period reduced to last month). The only non-inclusion criteria were inability to understand French and not living in France.

Consenting participants fulfilling the inclusion criteria were included by phone by a psychiatrist or a neuropsychologist. Participants were allocated to groups via a computer-generated randomization list with a 1:1 ratio, balanced by blocks of variable and undisclosed size. Participants were blinded to their group, with no indication of our hypothesized superiority of one over the other, and were told that both programs involved cognitive training. The information letter mentioned “In the proposed research, we are going to compare two online computerized cognitive training programs. You will receive one of the two programs in a random draw. You will not know which training program you will receive.”

## Interventions

Participants were called back within a 3-day period by a neuropsychologist to complete the initial assessments (baseline). During this call, the online data collection process and the appropriate training program were presented.

Participants were instructed to use the online training twice a week at home via internet, for 6 weeks. The advised duration for one online training session was 30 min, thus 1 h per week. A phone debriefing, of up to 15 min, twice a week, was offered to both groups. The guidance followed a semi-structured framework including a focus on the emotion associated with the task completion and on the transferability of the tasks in daily life. The neuropsychologist had access to participant performance via the therapist interface of the training platform.

Experimental and control programs were displayed on the same online platform and comprised six exercises. Twelve predetermined levels were available for each exercise: from the simplest to the most difficult. The exercises were contextualized and gamified. Detailed descriptions of the tasks and the instructions for the six exercises were detailed in a previous article (Santiago et al., 2021). Below are the brief descriptions of the exercises.

**Experimental intervention.** The cognitive training was a computerized cognitive training targeting inhibitory control of motor response derived by the existing validated program used in depression (Bowie et al., 2013). The exercises included

in the active program were selected and modified to target inhibition of the motor response, inhibition of interference and cognitive flexibility. Figure 1 shows the interface for the experimental intervention.

**Control intervention.** The control intervention consisted in a sensorial program with six exercises targeting visuo-constructive functions including visual exploration. Figure 2 shows the interface for the experimental intervention.

Both programs were attention demanding.

## Measures

Sociodemographic data (age, sex, employment) and smoking status were collected at baseline. Depression was screened using the MINI 6.0 and alcohol dependence using the AUDIT-C. The MINI, is a semi-structured interview based on the DSM-IV criteria (Pinninti, Madison, Musser, & Rissmiller, 2003; Sheehan et al., 1998), encompasses modules for 17 psychiatric diagnoses, including current major depressive episode. Questions within the MINI are structured to elicit only “yes” or “no” responses and can be completed online.

Audit-C screening for alcohol dependence (Bush, Kivlahan, McDonell, Fihn, & Bradley, 1998). The Alcohol Use Disorders Identification Test (AUDIT) was developed by the World Health Organization (WHO) as a screening tool for alcohol misuse and dependence. The AUDIT-C is a shortened version consisting of the first three questions of the full AUDIT, with responses scored on a scale of 0–4 for each question. Scores from the three questions are summed, with a total score ranging from 0 to 12. Higher scores indicate a higher likelihood of alcohol misuse or dependence.

The primary outcome was the change over 6 weeks in the French version of the PGSI-recent, a modified version of Problem Gambling Severity Index (PGSI) (Ferris & Wynne, 2001) with a 30-day recall period. The change in PGSI-recent by 14 weeks was measured as a secondary outcome. E-mails were sent to remind participants to complete the online assessments. If no response, they were called to collect data by phone.

Secondary outcomes were impulsivity, general health status, gambling related quality of life and gambling behavior (money and time spent) and were assessed at 6 and 14 weeks. The number and length of debriefing sessions was also recorded. Impulsivity was measured using the short form Urgency, Premeditation, Perseverance, Sensation seeking, Positive urgency, (UPPS-P) Impulsive behavior scale (Billieux et al., 2012; Whiteside & Lynam, 2001). The UPPS-P assesses five facets of impulsivity: Urgency, Premeditation, Perseverance, Sensation seeking, and Positive urgency using Likert-type response options. Scores are calculated for each facet of impulsivity, with higher scores indicating higher levels of impulsivity. Gambling characteristics of online and offline practice, and last 28-days loss in gambling were assessed by the TimeLine Follow Back (TLFB)-gambling (Sobell, Brown, Leo, & Sobell, 1996). General health status was assessed by the EQ-5D and quality of life was measured using a gambling-specific questionnaire, the Gambling Quality of Life Scale (GQoLS) (adapted





Fig. 1. Interface for the experimental intervention

Legend: 1st Box (Top Left)- Title: Don't Be Tempted - Description: Manage several pieces of information at the same time, but choose the correct one. 2nd Box (Top Center): Title: Gulf Stream - Description: Quickly indicate if your target is in your visible field. 3rd Box (Top Right)- Title: Catch the Ladybug - Description: Click as quickly as possible on all your targets and avoid intruders. 4th Box (Middle Left) - Title: Find Your Way - Description: Repeat the progression order on a path, forwards or backwards depending on the instruction. 5th Box (Middle Center) - Title: High Voltage - Description: Identify the position of your target among other distractor items. 6th Box (Middle Right) - Title: Don't Fall for It! - Description: Identify the correct target and click elsewhere if it is not the required symbol. Buttons: Info/Test

from Alcohol Quality of Life Scale, ongoing validation study) (Bonfils et al., 2022). The GQoLS is a 51-item self-questionnaire assessing impact of gambling on quality of life, using Likert-type response options, with a 6-week recall period, with the higher scores indicating higher levels of impact. The acceptability of the intervention was assessed by the number of sessions undertaken and the total length of training.

Data on gambling measures will be retrieved from the ANJ database at baseline, week 6, 14 and 52 and will be reported in future article because not available to date.

### Expected effect sizes and required sample size

The sample size was based on an anticipated between-group change difference on the PGSI of 3 points  $\pm$  5 points. We estimated a lost to follow-up rate at 6 weeks of 55% maximum (Luquiens et al., 2016). With a power of 80% and a two-sided type I error rate of 5%, 200 patients were needed (100 in each group).

### Data analysis

The analysis was performed as intention to treat (ITT). Statistical analyses were performed with SAS software version 9.2 (SAS Institute, Cary, NC). A multiple imputation approach was used to replace missing values where appropriate.

**Analysis of the primary outcome.** The change in PGSI-recent total score over 6 weeks was compared with the student's *t*-test.

**Analysis of secondary outcomes.** The change over time of secondary outcomes was compared with a linear mixed model. Fixed effects introduced in the model were time, randomization group and interaction between time and randomization group. The need for a model with random intercept and slope (versus random intercept only) was assessed at the time of the analysis with a likelihood ratio test. The number and the length of training sessions (acceptability) and the number and length of debriefing sessions (level of guidance) were compared using *t*-tests or Wilcoxon tests, as appropriate.

**Sensitivity analyses.** Exploratory sensitivity analyses on the primary outcome were performed on non-imputed data in the subgroup of participants who attended at least one session of training and in the subgroup of participants with no face-to-face help from an addiction specialist during the training period, as this face-to-face help is expected to have a larger effect size than the intervention and could have biased the groups because more participants from the control group attended face-to-face help.

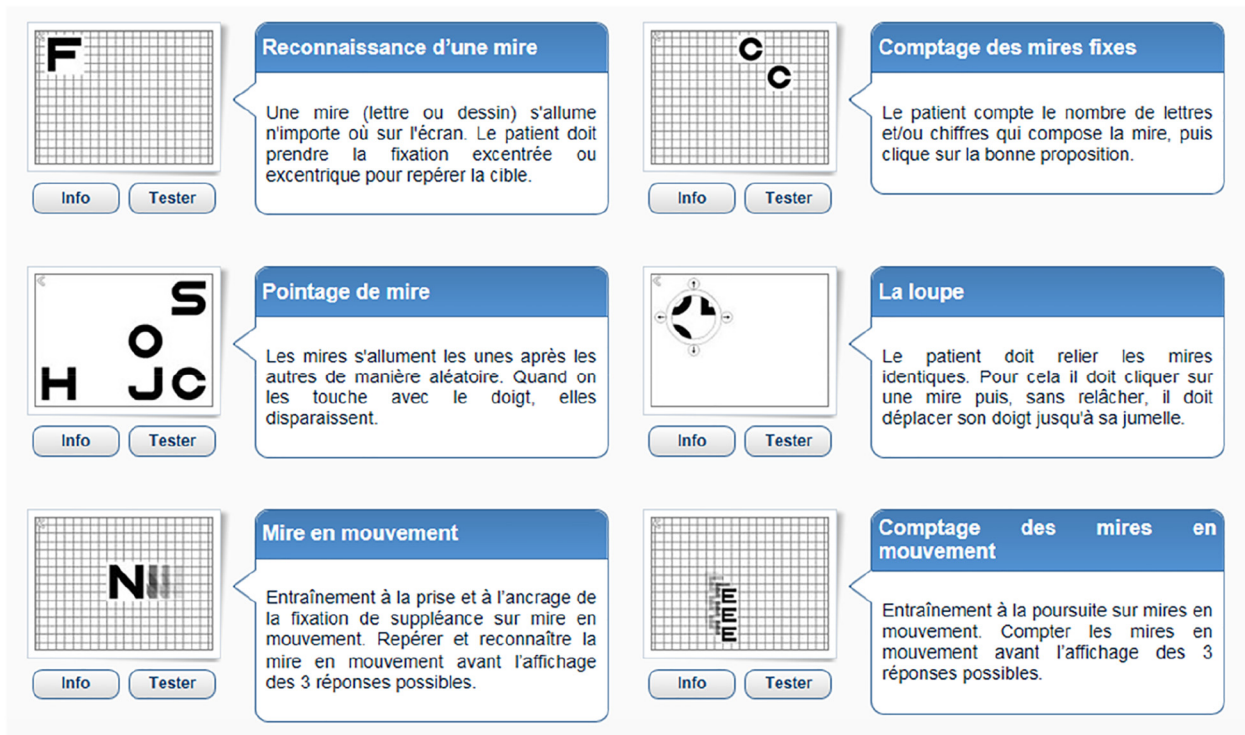


Fig. 2. Interface for the experimental intervention

Legend: 1st Box (Top Left)- Title: Recognition of a Target - Description: A target (letter or shape) lights up randomly on the screen. The patient must point to its location by selecting the right eccentricity to identify the side. 2nd Box (Top Center): Title: Counting Fixed Targets - Description: The patient counts the number of identical letters or shapes, then clicks on the correct answer. 3rd Box (Top Right)- Title: Target Pointing - Description: Targets light up one after the other in a random order. When touched with the finger, they disappear. 4th Box (Middle Left) - Title: Target in Motion - Description: Training in taking and anchoring fixation on a moving target. The patient must follow the moving target and choose the correct answer from 3 possible answers. 5th Box (Middle Center) - Title: Magnifier - Description: The patient must find identical targets. They can click on a target to zoom in, then remove their finger to zoom out. 6th Box (Middle Right) - Title: Counting Targets in Motion - Description: Training in following multiple moving targets. The patient counts the targets in motion and selects the correct answer from the 3 possible options. Buttons: Info/Test

## Ethics

The participants' free and informed oral consent were obtained by phone during enrolment. The participant confirmed consent by ticking the box indicating their free acceptance to participate on the online form (Cleanweb®). This study was executed in compliance with the Helsinki Declaration, and was approved by the CPP (Committee for the Protection of Persons) in October 2017 n° 2017-A01666-47. Trial registration number: NCT03673800.

## RESULTS

### Sample characteristics

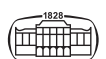
During the recruitment period, 187 participants were screened, with two excluded due to an PGSI score < 5 or who were unreachable within 3 days of applying. The remaining 185 participants were randomized: 93 to the experimental group and 92 to the control group. The recruitment was stopped by the promotor before the targeted size of 200 after reaching the end of the authorized study length and no

further extension was authorized by the promotor since the investigator had changed of institution in between. The flow chart is presented in Fig. 3.

Mean age was 39.2 (12.4) years and 79.5% of participants were male. 66.5% of participants were employed, and 4.9% students. 40% were tobacco smokers. Half had a concomitant alcohol use disorder (50%), and 3.8% were currently depressed. Mean PGSI-CPGI score was 15.2 ( $\pm 5.5$ ). Most participants did not attend face-to-face care with an addiction specialist at inclusion (78.4%). There was a 56.8% drop out rate at week 6, rising to 77.9% at week 14. Table 1 presents baseline characteristics.

### Observance

One third of participants ( $n = 53$ ) never trained on the platform ( $n = 21$  (23%) in the experimental group, and  $n = 32$  (35%) in the control group). Half the participants in the experimental group attended 3 sessions or more vs 2 or more in the control group ( $p = 0.09$ ). Figure 4 presents the number of sessions attended. The median total training time was 38 [6–143] minutes in the experimental group vs 23 [0–95.75] minutes in the control group ( $p = 0.15$ ).



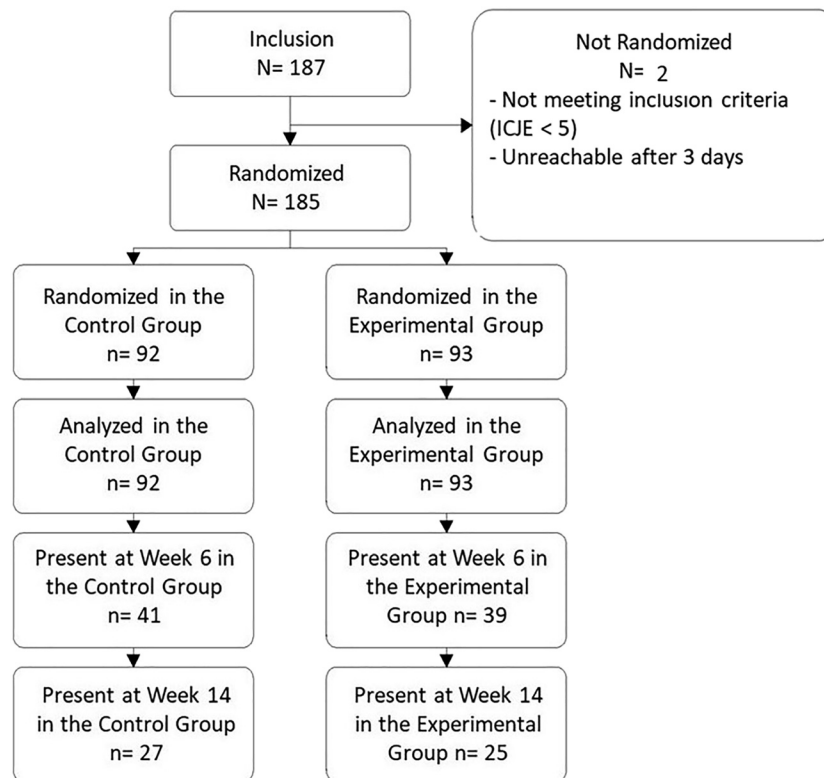


Fig. 3. Flow chart

Table 1. Baseline characteristics of participants

|   | Experimental group | Control group      |
|---|--------------------|--------------------|
| Sex, male   | 77 (82.8%)         | 70 (76.09%)        |
| Age, years  | 38.98 (13.22)      | 39.45 (11.5)       |
| Employed  | 59 (63.44%)        | 64 (69.57%)        |
| AUDIT-C score   | 4.07 (2.64)        | 3.87 (2.73)        |
| Smoker  | 34 (36.56%)        | 40 (43.48%)        |
| Current depression                                      | 3 (3.23%)          | 4 (4.35%)          |
| UPPS-S  |                    |                    |
| Total score   | 43.65 (7.45)       | 42.16 (5.66)       |
| Negative urgency  | 8.83 (2.8)         | 8.84 (2.7)         |
| Positive urgency  | 7.92 (2.27)        | 7.67 (2.34)        |
| Lack of premeditation                                   | 8.88 (2.7)         | 8.4 (2.47)         |
| Lack of perseverance                                    | 8.73 (2.74)        | 8.23 (2.78)        |
| Sensation seeking                                       | 9.17 (3.11)        | 8.87 (2.58)        |
| <b>Gambling characteristics</b>                         |                    |                    |
| PGSI total score  | 15.61 (5.47)       | 14.82 (5.47)       |
| Online gambling   | 72 (77.42%)        | 72 (78.26%)        |
| Offline gambling  | 84 (90.32%)        | 85 (92.39%)        |
| Last 28-days loss, €                                    | 1398.2 (2875.81)   | 3798.28 (13136.25) |
| GQoLS total score                                       | 75.01 (27.95)      | 69 (27.94)         |
| Consultation with an addiction specialist in past month | 19 (20.43%)        | 21 (22.83%)        |

## Outcomes at 6 and 14 weeks

**Description of evolution on non-imputed data.** Table 2 presents the change at 6 and 14 weeks on impulsivity and gambling characteristics.

Figure 5 presents the distribution of the change in PGSI score at 6 weeks. The mean change in PGSI-recent score between baseline and 6 weeks was  $-3.27$ , 95% CI  $[-4.26; -2.28]$  in the experimental arm versus  $-2.55$ , 95% CI  $[-3.79; -1.32]$  in the control arm. One third of participants were classed as no longer problem gamblers at week 14 (34.1%).

**Efficacy analyses on imputed data.** On imputed values, the mean change in PGSI-recent score between baseline and 6 weeks was  $-2.75 (\pm 5.2)$  in the experimental arm versus  $-2.44 (\pm 5.65)$  in the control arm ( $p = 0.76$ ).

**Sensitivity analyses of the primary outcome on non-imputed data.** In the subgroup of participants with no face-to-face help from an addiction specialist during the training period, the mean change in the PGSI-recent score between baseline and 6 weeks was  $-3.52 (\pm 5.01)$  in the experimental arm versus  $-2.03 (\pm 5.87)$  in the control arm ( $p = 0.31$ ,  $n = 58$ ). Subgroup analysis of participants who attended at least one session of training found a mean change in PGSI-recent score between baseline and 6 weeks of  $-2.74 (\pm 4.24)$  in the experimental arm versus  $-2.19 (\pm 5.71)$  in the control arm ( $p = 0.68$ ,  $n = 63$ ). No significant change was found for any of the secondary outcomes.

## DISCUSSION

We found no significant difference between groups at 6 and 14 weeks in the primary outcome (i.e. the change in PGSI-

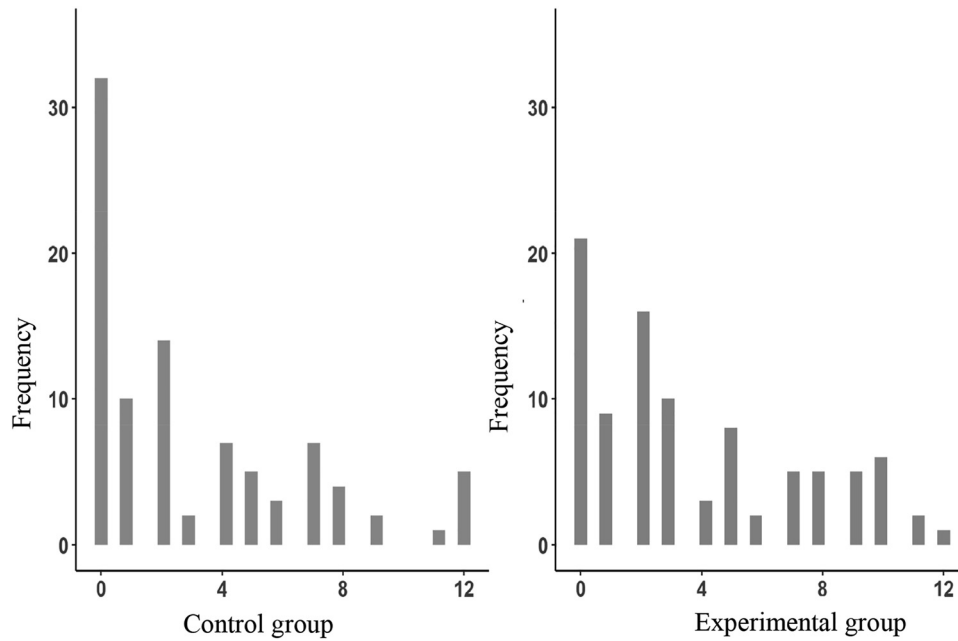
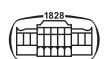


Fig. 4. Distribution of number of sessions by arm

Table 2. Change at 6 and 14 weeks of impulsivity and gambling characteristics between groups (non-imputed data)

|                                 | Experimental group mean (sd) | Control group mean (sd) | Difference in the change between groups between follow-up and baseline [95% CI] |
|---------------------------------|------------------------------|-------------------------|---|
| <b>Gambling characteristics</b> |                              |                         |   |
| <b>PGSI total score</b>         |                              |                         |   |
| Week 6 (n = 68)                 | 11.77 (5.13)                 | 11.89 (6.66)            | -0.74 [-3.49; 2]  |
| Week 14 (n = 44)                | 9.3 (5.77)                   | 8.54 (7.4)              | -0.01 [-3.17; 3.15]   |
| <b>PGSI &lt; 5, n (%)</b>       |                              |                         |   |
| Week 6 (n = 68)                 | 3 (10%)                      | 6 (15.79%)              |   |
| Week 14 (n = 44)                | 6 (30%)                      | 9 (37.5%)               |   |
| <b>Last 28-days loss, €</b>     |                              |                         |   |
| Week 6 (n = 71)                 | 897.91 (2271.38)             | 1497.46 (4815.84)       | -162.06 [-1715.21; 1391.1]  |
| Week 14 (n = 44)                | 261.82 (1642.95)             | -87.32 (2068.87)        | 63.55 [-1724.33; 1851.43]   |
| <b>GQoLS total score</b>        |                              |                         |   |
| Week 6 (n = 65)                 | 38.61 (23.56)                | 42.03 (29.42)           | -5.06 [-17.06; 6.93]  |
| Week 14 (n = 41)                | 25.37 (20.97)                | 25.95 (29.08)           | -3.71 [-17.78; 10.35]   |
| <b>UPPS-S</b>                   |                              |                         |   |
| Week 6 (n = 57)                 | 42.79 (5.73)                 | 45.15 (6.19)            | -1.98 [-4.77; 0.81]   |
| Negative urgency                | 9.46 (2.17)                  | 9.7 (2.7)               | -0.51 [-1.51; 0.48]   |
| Positive urgency                | 8.38 (1.95)                  | 9.12 (2.36)             | -0.58 [-1.5; 0.33]  |
| Lack of premeditation           | 8.08 (2.32)                  | 7.94 (2.29)             | 0.11 [-0.69; 0.91]  |
| Lack of perseverance            | 7.92 (2.47)                  | 8.27 (2.97)             | -0.32 [-1.2; 0.55]  |
| Sensation seeking               | 8.96 (2.48)                  | 10.12 (2.5)             | -0.61 [-1.54; 0.31]   |
| Week 14 (n = 42)                | 43.32 (5.58)                 | 42.04 (8.76)            | 1.25 [-1.94; 4.45]  |
| Negative urgency                | 10.42 (1.98)                 | 9.38 (3.13)             | 0.64 [-0.51; 1.78]  |
| Positive urgency                | 8.79 (1.44)                  | 8.42 (2.32)             | 0.05 [-0.98; 1.08]  |
| Lack of premeditation           | 7.47 (2.12)                  | 7.48 (2)                | 0.07 [-0.81; 0.95]  |
| Lack of perseverance            | 8.05 (2.37)                  | 7.5 (1.98)              | 0.13 [-0.83; 1.08]  |
| Sensation seeking               | 8.58 (2.14)                  | 9.38 (2.52)             | 0.18 [-0.88; 1.25]  |

A negative difference in the change means a larger decrease at 6/14 weeks as compared to baseline, in the experimental group than in the control group, of the size of the corresponding value.



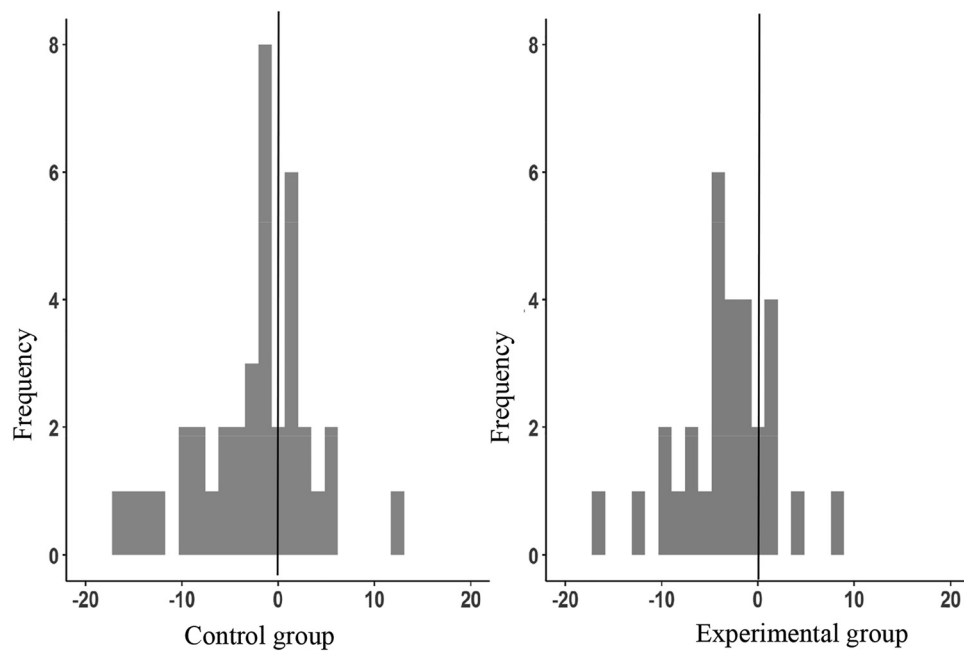


Fig. 5. Distribution of change in PGSI-recent score from 0 to 6 weeks (a negative score means a decrease in PGSI score)

recent score at week 6), and in any the secondary outcomes, even in sensitivity analyses. The internet plus telephone intervention was moderately acceptable in this mixed population of problem gamblers with or without addition face-to-face professional help outside the intervention. One third of the participants never trained on the platform. The total training time and frequency were much lower than recommended in the instructions (recommended 1hr per week, actual total time 38 min in experimental versus 23 min controls). The mean between-group PGSI difference was lower than expected at week 6 and did not reach clinical (a priori defined as 3 points) or statistical significance.

However, both groups improved in gambling behavior and impact of gambling in quality of life, suggesting potentially relevant management strategies in both arms. Both groups showed a mean PGSI-recent score decrease of 6.3 points and one third of participants were no longer problem gamblers at week 14. We further confirm recent findings demonstrating the efficacy of low intensity interventions (Mide et al., 2023). While half of participants dropped the computerized training programs after 2 or 3 sessions (i.e. first or second week), nearly half of participants provided follow-up data at week 6 by mail or phone. The weekly telephone guidance being common between the 2 groups, it could be at least partly responsible for the observed improvement. The interaction between the problem gambler and the therapist has been previously reported as a core component of success of non-face-to-face interventions (Jonas et al., 2020). Our study supports the relevance of this interaction by phone and more globally supports keeping human guidance in non-face-to-face interventions, unlike claimed in a recent study (So et al., 2024). However, the GAMBOT2 study compared an unguided

self-help chatbot-delivered cognitive behavioral therapy and in the control group the same intervention added by a limited human guidance through personalized feedback messages with no interactions and no voice exchange (So et al., 2024). There is then no contradiction between our results and theirs. A real interaction may be critical to maintain and motivational support, which is one of the key practices and recommendations, needs to be implemented even in non-face-to-face interventions. In addition, the development of a therapeutic alliance through the telephone calls may have increased participants' motivation. Although not significant, the between-group difference in PGSI was greater for participants who did not benefit from face-to-face help during the training period and for whom the study was the only source of help. For these participants, direct human interaction by telephone may have been very helpful. This is consistent with the intermediate dropout rate found in our study, which falls between the low rates found in online interventions recruiting face-to-face treatment seekers in clinical settings, around 20% (Stenbro, Moldt, Eriksen, & Frostholm, 2023), and the very high dropout rates in fully online interventions among non-treatment seekers, around 80% (Luquiens et al., 2016; Nikolaos Boumparis et al., 2023). Our initial aim to propose an alternative modality of care was partially fulfilled as three-quarters of our sample did not benefit from face-to-face help at inclusion. However, being unready to attend face-to-face care also seems to be associated with a lower motivation and larger dropouts from therapeutic programs (Dunn, Delfabbro, & Harvey, 2012), with the inverse true when recruiting for non-face-to-face intervention in patients already seeking treatment in face-to-face settings (Stenbro et al., 2023). These insights are particularly relevant to the implementation of prevention programs from a digital,

non-face-to-face perspective. A low motivation to change could have lowered the adherence to the training programs, and thus could have limited the effectiveness of cognitive training. The nature of the training regime including the intensity and the duration of the program could influence its success (von Bastian & Oberauer, 2014). It should be taken into account in future studies assessing non face to face interventions. Another adaptation of the program could be to propose cognitive training personalized to neurocognitive impairments, as it has recently been demonstrated that problem gamblers may have different neurocognitive profiles, some more affected by cognitive flexibility, others by inhibition impairments (Baenas et al., 2024). More generally and given the high rates of comorbid mental health conditions to gambling disorder, tailoring treatment plans should be applied in practice to address the specific challenges associated with gambling disorders (Moreira, Dias, Azeredo, Rodrigues, & Leite, 2024; Szerman et al., 2020). Finally, recent data from a community-recruited sample with alcohol use disorder suggested that working memory training had a similar efficacy to visuo-spatial training on reduction in drinking (Finn et al., 2022). We cannot rule out that our visuo-spatial control intervention had an effect on gambling behavior, likewise, we cannot exclude the active involvement of visuo-spatial processes in this experimental program associated with inhibitory control.

Our study has limitations. We encountered recruitment difficulties and had to stop the recruitment before the targeted sample size ( $n = 185$  vs 200 calculated) leading to a lack of power. Beyond difficulties due to the COVID crisis, the difficulties in recruiting despite a broad national media coverage support previous findings that problem gamblers are a hard-to-reach population (Muggleton & Stewart, 2021) and that multiple devices for help should be proposed, alongside initiatives to decrease stigma (Brown & Russell, 2020) and increase lay person knowledge on problem gambling. The low rate of females in our sample reflects both the higher prevalence in males but also the higher level of self-stigma among women with problem gambling that is a recognized barrier to treatment (Kushnir, Godinho, Hodgins, Hendershot, & Cunningham, 2016). However, this had probably little impact on the results as the motivation to change does not seem to be gender-related in problem gamblers (Kushnir et al., 2016). In addition, dropout rates have also been previously demonstrated to be sensitive to gender and age, young males being more prone to dropout from e-interventions in addictive disorders (Wen et al., 2021). Our sample combines these characteristics, but our attrition rate falls in the expected level as mentioned above. However, we have no indication of reasons for dropping out. It could be that participants found the intervention annoying or didn't see how it could help them. As regarding the gamification of the task, Boendermarker et al. demonstrated that expectations could be higher as compared to regular tasks, and therefore if the gamification is minimal, participants could be disappointed and motivation could be lower than for regular tasks (Boendermarker, Sanchez Maceiras, Boffo, & Wiers, 2016). Moreover, to maintain the

blind condition, the same explanations were provided to both groups on our hypothesis that training inhibition could help reduce gambling by lowering impulsivity and increasing the “stop” abilities of the brain. However, the neuropsychologist felt that the people involved in the cognitive training program understood the link between the hypothesis and the exercises better than the control group, although this was not systematically recorded for each patient, so this information should be taken with caution. The fact that the debriefing was conducted by an unblinded neuropsychologist could have biased the conduct of the debriefing; however, the debriefings followed the same structured steps in both groups, which should have limited this bias. The understanding of the underlying model could be critical to engage in cognitive training, particularly when general abilities are trained independently of any addiction relevant cue. Lack of social support and barriers to internet use could also have limited the engagement in the internet intervention as in other fields (Blacket et al., 2024) and could have been registered.

The overall impulsivity score was not sensitive to training in either group. In line with recommendations, we used an in-depth analysis of impulsivity (Billieux et al., 2012). The relationship between cognitive inhibition and impulsivity at the behavioral level and the impact of an intervention on the former or latter is not easy to demonstrate. We could have assessed other components of impulsivity beyond impulsive actions and in particular impulsive choice (Wang et al., 2016), by decision-making processes that is also related to severity and remission in addictive disorders (Awo, Amazue, & Oko, 2022; Galkin, 2023).

Finally, we collected gambling behavior from different perspectives: the gamblers, i.e. subjective patient-reported outcomes and long-term, up to 12 months of follow-up, objective account-based gambling data from regulated gambling service providers routinely registered at the regulator (National Authority of gambling “ANJ”). This data is currently being analyzed and will be presented in a subsequent article. Given the poor reliability of self-reported gambling intensity and losses in problem gamblers (Heirene, Wang, & Gainsbury, 2022), these objective long-term data will provide interesting insights on this randomized trial.

In conclusion, our results allow to draw a number of recommendations for future studies: (1) to propose a control intervention with exactly the same conditions of administration, but with a pre-assessed neutral component. (2) if the task is gamified, to pre-assess the enjoyment of the task in order not to disappoint the participants. (3) more globally, to pre-assess the acceptability of the training program and frequency in the target population (4) if possible, to state in the inclusion criteria whether the population could already benefit from face-to-face care at inclusion.

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*Authors' contribution:* AL and AC wrote the first draft of the paper. All authors conceived the study and revised the



manuscript for relevant scientific content. All authors approved the final version of the manuscript.

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## SUPPLEMENTARY MATERIAL

Supplementary data to this article can be found online at <https://doi.org/10.1556/2006.2024.00080>.

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