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The Prevention of Adolescent Problem Gambling Through Probabilistic Reasoning: Evidence of the Intervention's Efficacy

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Abstract Preventive efforts are necessary to reduce the risk for problem gambling among adolescents, especially among more at-risk youth. However, only a small proportion of the preventive initiatives implemented in the field of adolescent problem gambling are based on robust theoretical models and have been evaluated in their efficacy. By referring to the dual-process model of human functioning, especially to the mindware concept, the goal of this study was to develop and evaluate a school-based preventive intervention based on teaching probabilistic reasoning ability and explaining biases in reasoning with probability. Indeed, research with adolescents found that poor probabilistic reasoning ability is associated with gambling-related cognitive distortions that, in turn, are a risk factor for problem gambling. The study aim was to reduce gambling-related distortions by working on the concept of randomness and probability. A pre- and post-test design was performed with 72 adolescents randomly assigned to a Training group and a No Training group. Results showed a significant reduction of cognitive distortions at the post-test only in the Training group. Findings suggest that teaching probability can serve to reduce the susceptibility to gambling-related distortions and should be pointed out in the training process of the intervention providers in the gambling field.

Résumé Il est nécessaire de faire des efforts de prévention pour réduire les risques de dépendance au jeu chez les adolescents, en particulier parmi les jeunes qui sont à risque. Toutefois, seulement quelques-unes des mesures préventives mises en œuvre pour lutter contre la dépendance au jeu chez les adolescents sont fondées sur des modèles théoriques étoffés et peu ont été évaluées sur le plan de leur efficacité. En lien avec le modèle de fonctionnement humain à double processus, notamment le conceptuel, l'objectif de cette étude consiste à élaborer et à évaluer une intervention préventive centrée dans le milieu scolaire qui est fondée sur l'enseignement de compétences en raisonnement probabiliste et une explication des biais existants dans le raisonnement probabiliste. À n'en pas douter, des travaux de recherche effectués avec des adolescents ont montré une association entre une faible compétence en raisonnement probabiliste et des distorsions cognitives liées au jeu, ce qui devient un facteur de risque pour une dépendance au jeu. Cette étude vise à réduire les distorsions liées au jeu en travaillant sur les

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concepts de l'aléatoire et de la probabilité. On a assigné au hasard 72 adolescents dans deux groupes, l'un a reçu une formation, mais pas l'autre groupe puis on a soumis ces jeunes à un plan comportant un prétest et un test de contrôle. Les résultats démontrent une réduction importante des distorsions cognitives au test de contrôle, seulement dans le groupe ayant bénéficié d'une formation. Ces constatations semblent indiquer qu'enseigner la probabilité peut s'avérer utile pour amenuiser les risques de distorsions liées au jeu et cela devrait être mis en valeur dans la démarche de formation des intervenants dans le domaine du jeu.

Keywords Teaching probability · Prevention · Gambling · At-risk adolescents · Intervention · Evaluation

Despite the restrictions to gamble for youth minor than 18 years, gambling is a very popular activity among adolescents. Prevalence studies report that many juveniles are involved in gambling activities. A recent systematic review reported that adolescents' gambling prevalence rates across the world range from 35.7 to 74.4% (Calado et al., 2017), and Bottella-Guijarro et al. (2020) found that 12–70% teenagers in Europe report having gambled in the last 12 months. Concerning Italy, the latest ESPAD (European School Survey Project on Alcohol and Other Drugs, 2019) epidemiological survey conducted in 2019 in 35 European countries by the Italian Institute of Clinical Physiology of the National Council of Research (IFC-CNR) showed that out of 96,783 adolescents between the ages of 15 and 19, 32% report having gambled on at least one gambling activity in the past 12 months. This trend has been confirmed in the ESPAD 2020 report, in which it emerged that, out of 6027 Italian teenagers between 15 and 19 years, 44% have gambled at least once in the past 12 months. Instant scratch cards are the most popular activities, followed by sports betting and card games for money. It is also important to highlight that 17% gambled 2 to 4 times a week and 2% more than 6 times a week, and that 44% of minors gambled at least once in the last few years (Biagioni & Molinaro, 2020).

This data is alarming as initiation of gambling at an early age is associated with higher risk of more severe gambling problems in adulthood (see Volberg et al., 2010, for a review). Moreover, the increasing growth of gambling opportunities and the easy accessibility to gambling activities via smartphone and Internet has led to the increase in the prevalence of adolescent problem gambling (e.g., Andrie et al., 2019) that can be defined as a wide array of negative consequences derivable from excessive and persistent gambling at a physical, psychological, economic, and social level (Ferris & Wynne, 2001).

Due to the potential negative consequences derived from gambling, prevention of problem gambling among adolescents has increasingly become an important area of concern in research and practice. There has been an increasing interest in developing and evaluating preventive initiatives for adolescents, especially in the school context (see, for a review, Keen et al., 2017). Among them, several interventions have been directed on modifying knowledge and misconceptions about gambling (e.g., Capitanucci et al. 2010; Ferland et al. 2005; Ladouceur et al. 2005; Lavoie & Ladouceur, 2004), in line with a cognitive-developmental approach to gambling education (Keen et al., 2019). However, many of them have been developed in absence of an explicitly described theoretical model (Ladouceur et al., 2013; St-Pierre et al., 2015) and, even when a theoretical model has been proposed, it was adapted from other addictions' prevention approaches, or it is often unclear how the theory was used in the program development (Keen et al., 2017; St-Pierre et al., 2015, for reviews).

Following this premise, the goal of the present work was to verify the efficacy of a preventive intervention focused on *gambling-related cognitive distortions*, i.e., irrational cognitions and thoughts that comprise a wide array of erroneous interpretations of gambling outcomes as they are based on incorrect links between the cause and the effect, superstitiously based beliefs, personification of the gambling instruments (e.g., the machines), reference to personal skill or luck as an explanatory

or predictive factor of the gambling outcomes (Goodie et al., 2019). Following a previous model tested with adolescents (Donati et al., 2018), we focused the educational activity on the concept of randomness understanding that is an important prerequisite skill to reduce susceptibility to gambling-related cognitive distortions (Keen et al., 2017). Indeed, although various and different cognitive distortions exist in relation to gambling, all of them are characterized by a common denominator that consists in a violation in understanding the concept of randomness.

Some cross-sectional studies revealed that adolescent problem gamblers did not differ from non-problem gamblers in terms of their knowledge of objective odds or probabilities and did not necessarily have poorer knowledge of mathematical principles or gambling odds than non-problem gamblers. Nonetheless, they were more prone to mistaken views about randomness when compared with non-problem gamblers, and they held erroneous beliefs about their chance of winning (Delfabbro et al., 2009). According to Turner et al. (2008), many of these erroneous beliefs center on the topic of independence of random events, such as the gambler's fallacy, a well-known bias in probabilistic reasoning stemming from the belief that the likelihood of an event is related to preceding, independent outcomes.

Irrational beliefs about gambling are risk factors of problem gambling in youth (e.g., Delfabbro et al., 2009). Indeed, adolescent problem gamblers have erroneous beliefs about their chances of winning, and are susceptible to biases related to gambling outcomes (e.g., Turner et al., 2006). Specifically, they have cognitive biases such as the perception of gambling as an activity involving a considerable element of skill, and the belief that they can exercise control over the slot machines they play. More in detail, three distortions are based on previous gambling research, including *Illusion of Control* (IC), *Predictive Control* (PC), and *Interpretative Bias* (IB). IC refers to the belief that one can determine gambling outcomes both actively, thanks to personal skill or knowledge, and passively, for example, through interpreting good luck in other areas of life as signs of imminent success in gambling. PC entails the belief that one can predict gambling outcomes on the basis of salient cues, such as previous outcomes. IB refers to an erroneous attribution of causality based on a distorted reframing of gambling outcomes, consisting for example adopting an internal locus of control for wins in contrast to an external locus of control for losses (Raylu & Oei, 2004).

Among the models that have been considered as theoretical frameworks to develop preventive interventions, there is the dual-process model (see Stanovich, 2004, for a review). This model has been used by Toplak et al. (2007) to explain the irrationality of people while gambling. In detail, it could be that people fail to be rational in gambling when there is a mindware gap, when the set of rules, procedures, and strategies derived from past learning experiences are lacking. Additionally, referring to gambling arises when there are paranormal beliefs and superstitious and magical thinking that contaminated the mindware.

Based on the work of Toplak, a recent study (Donati et al., 2018) tested if the dual-process model can be used to explain gambling behavior also in adolescents. In detail, this work showed that susceptibility to the gambler's fallacy (as the operationalization of mindware gap) and superstitious thinking (as contaminated mindware) predict gambling-related cognitive distortions that, in turn, affect gambling frequency and problem gambling. In sum, gambling-related cognitive distortions have a role in mediating the relationship between probabilistic reasoning ability and superstitious thinking to problem gambling. More specifically, cognitive distortions seem to be affected by high levels of superstitious thinking and poor probabilistic reasoning abilities.

The aim of this work was to evaluate a targeted preventive intervention, i.e., an intervention addressed to adolescents with a high risk for gambling problems. The characteristics that are reported in literature as defining more risks for adolescents are being male (e.g., Donati et al., 2013), having a poor school achievement (e.g., De Luigi et al., 2018), performing other at-risk behaviors, i.e., cannabis and alcohol use (Peters et al., 2015), and having a status of immigrants (e.g., Canale et al.,

2017). To the best of our knowledge, there are few studies on this topic and there is a lack of studies attesting the efficacy with high-risk samples (Allami & Vitaro, 2015; Ladouceur et al., 2013).

We hypothesized that fostering adolescents' ability to a correct comprehension of randomness and to a resistance of fallacies inside gambling contexts may have helped them not adhere to distorted cognitions about gambling outcomes. It has been suggested that misunderstanding of probability can lead to irrational thoughts and behaviors related to gambling, such as chasing or obtaining false contingencies (Raylu & Oei, 2004). As reviewed by Goodie and Fortune (2013), misrepresentations about the chance of winning can derive from the representativeness heuristic, i.e., a tendency for people to base their judgment of the probability of a particular event on how much it represents the essential features of the parent population or of its generating process (Kahneman et al., 1982) and associated biases. For instance, one of the most documented biases related to gambling is *the gambler's fallacy*, which occurs when individuals believe that even short strings of random events must correspond with their perception of what constitutes randomness, leading to beliefs that particular outcomes are "due" (Tversky & Kahneman, 1971).

In sum, we considered that through the improvement of probabilistic reasoning ability, we could expect a reduction of specific gambling-related distortions, i.e., the IC, the PC, and the IB. To evaluate changes in these variables over time as a function of treatment condition, an experimental design was conducted with two groups (Training vs. No Training) and two measurements (pre-test and post-test sessions).

Methods

Participants

Participants were 72 adolescents (89% males, mean age = 16.87, $SD = 1.14$ years) attending technical high school in a neighborhood of Florence (Italy). From the available schools in the area, one school was randomly selected. Subsequently, the school's principal was contacted, apprised of the issue of adolescent problem gambling to generate support for the research, and he was presented with the project. Once the school agreed to participate, the detailed study protocol was approved by the institutional review board of the school. Written informed consent was requested from students (or their parents, if they were minors), assuring them that the data would be handled confidentially. The research was conducted during school time and all students invited to participate agreed to do so. The sample could be classified as an at-risk adolescent subpopulation as it had some characteristics that are reported in literature as risk factors: it was predominantly composed by adolescent boys, there were high levels of socio-economic inequality, there was a large prevalence of other at-risk behaviors (i.e., cannabis and alcohol use), poor school achievement, and also a large proportion of immigrants (Società della Salute, 2009).

Measures

The *Gambling Related Cognitions Scale – Revised for Adolescents* (GRCS-RA; Raylu & Oei, 2004; Italian version: Donati & Primi, 2021) is a self-report scale to assess gambling-related cognitions in young people, which contains 14 Likert-type items, rated on a 5-point scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). Three specific gambling-related biases, according to Toneatto's model (Toneatto, 1999), are measured by the following subscales: *Illusion of Control* (4 items), *Predictive Control* (6 items), and *Interpretative Bias* (4 items). Respectively, an example of item is "*In gambling praying helps you win*", "*In gambling, losses are necessarily followed by a series of wins*", and "*In gambling, if you continue to play because if you win is thanks to personal skills and abilities*". The scale has good psychometric properties

in adolescents (Donati et al., 2015a, b; Taylor et al., 2015). In this sample, Cronbach's alpha for the overall scale was 0.83.

The *Gambling Behavior Scale for Adolescents* (GBS-A; Primi et al., 2015) is a self-report scale to evaluate gambling habits and gambling disorder (GD) symptoms in adolescents. It is made up of two sections. Section I consists of unscored items investigating gambling behavior, among which gambling frequency in the last 12 months. Specifically, there are items assessing the frequency (*never*, *sometimes in the year*, *sometimes in the month*, *sometimes in the week*, *daily*) of participation during the last year in ten gambling activities (card games, bets on games of personal skill, bets on sports games, bets on horse races, bingo, slot machines, scratch cards, lotteries, online games, and private bets with friends). By summing responses to these ten items, a total score indicative of past-year gambling frequency can be obtained. For analysis purposes, options "*sometimes in the year*", "*sometimes in the month*","*sometimes in the week*", and "*daily*" were collapsed, in order to obtain a versatility score (range = 0–10) with respect to the gambling activities practiced. Moreover, participants were asked to report with whom they gamble (alone, with friends, with partner, with family members).

Section II was composed by nine items, each one developed in order to relieve one of the nine symptoms listed in the *Diagnostic and Statistical Manual of Mental Disorders – Fifth Edition* (DSM – 5; American Psychiatric Association, APA, 2013), provided on a 3-point Likert scale ranging from 0 (*never*) to 2 (*many times*). An example of item is "*Have you spent in gambling money intended for other purpose?*". The advantage of the GBS-A is that items assessing GD symptoms have been developed by applying Item Response Theory (IRT); thus, it can provide a measure of gambling problem severity taking into account the severity and the discrimination power of each symptom described by the items. Moreover, the total score allows for the classification of the young gamblers in "non-disordered", "at risk", or "disordered". The scale has good psychometric properties in adolescents (Donati et al., 2017; Primi et al., 2015).

Procedure and Design

An experimental design was conducted with two groups (Training vs. No Training) and two measurement sessions (pre-test and post-test). Participants were randomly assigned to each group.

The Training group consisted of 22 students (*M*age = 15.85 years, *SD* = .79) and the No Training group consisted of 50 students (*M*age = 17.31 years, *SD* = .98). For the Training group, participation involved filling out the above-described scales before the intervention (pre-test), receiving training activities, and filling out the GRCS-RA after the intervention (post-test). The pre-test scales (GRCS-RA and GBS-A) and post-test scale (only the GRCS-RA) were administered also to the No Training group. Nevertheless, while the Training group received the intervention, the No Training group continued with usual school activity. In the pre-test and post-test sessions, the scales were administered within the classrooms, and students were required to work individually. Administration of the instruments required approximately 30 min for the pre-test session and 15 min for the post-test session. After 1 week from the pre-test, the intervention began with the first didactic unit. After 1 week, there was the second didactic unit and after another week, the post-test was administered to both the groups. At the end of the post-test session, it was given feedback about the research and thanked the students for their participation.

The Intervention

Our intervention activities were based upon a model previously tested (Donati et al., 2018). The intervention included two didactic units implemented in class, during the school time conducted by an intervention provider trained about this model. Each didactic unit lasted about 2 h and was presented in a 2-week period (one per week).

In the intervention, we implemented activities in which adolescents could reinforce rules and knowledge concerning probabilistic reasoning and to recognize biases in reasoning with randomness. In detail, the first didactic unit began with the introduction of the gambling meaning and examples of gambling activities. Then, the concept of probability was introduced, in particular the independence of random events and equiprobable and non-equiprobable random events. As a subsequent step, adolescents had to apply the learned concepts to calculate the likelihood of buying a winning scratch card. In this didactic unit, they prepared a sample cutting from a paper sheet some colored squares (with a same number of black and white) and put all them in a bag. The task was to esteem the probability of the event black square in case of resampling. They also used different samples with a different proportion of black squares. In this way, they can esteem the probability with equally likely and non-equally likely outcomes.

The second didactic unit was focused on reasoning in probabilistic terms inside cold and hot contexts, in order to learn that a typically hot context like gambling makes adolescents more prone to be driven by emotion rather than rationality. More specifically, adolescents were first presented with the *Non-gambling Task* (Donati et al., 2015a, b), in which they were presented with six different outcome sequences consisting in six coin tosses (T = tails, H = heads). For each sequence, they were asked to indicate the likelihood of tail if a seventh toss would be made. After participants had compiled this first task, the *Gambling Task* (Donati et al., 2015a, b) was administered. In this task, participants were presented with the same outcome sequences as the *Non-gambling Task*, but, for each sequence, they were asked to indicate how much money, from a minimum of €0 to a maximum of €10 (available for each sequence), would bet on Tails if a seventh toss would be made. Through the consecutive administration of the two tasks, adolescents had first-hand experience of the switch occurring from *cold* situations, i.e., contexts in which there are not affective elicitations and this incentives the decision-maker to focus on the task and to apply the mindware resources, to *hot* situations, i.e., contexts in which there are some affective elicitations – in this task, a possible win in money – that make the decision-maker less adherent to his/her knowledge and competences and more susceptible to mindware contaminations. Then, the general meaning of cognitive distortion was introduced and subsequently, the unit focused on cognitive distortions related to gambling. The aim was to teach adolescents to understand that the incorrectness of the distortions relates to the lack of the cause-effect link among the events and to an erroneous interpretation of the cause of the events.

To that aim, each didactic unit had a specific structure: an introduction, where the intervention provider gave the instructions, individual work done by each student, collective discussions among participants guided by the expert, and finally a closure with a reworking/summary of the contains emerged during the activity. This way of proceeding allowed to bring out the preconception of students, to highlight the eventual wrong conception, to explain, and to reinforce the right one. This strategy followed the *conceptual change model* which explains that a prerequisite for new conception can be acquired if the old one is perceived as unsatisfactory (Posner et al., 1982).

Concerning the training techniques, we integrated a mixed set of techniques including activities with random events generators, Power Point presentations, and collective discussions. As for the methodology, each didactic unit included exercises in which students had to apply the learned ability/concept, and then they had to use the learned ability referring to fictitious gambling situations. In that way, training activities were aimed to promote the generalization of the proposed contents in real-life contexts. Concerning the procedure, each activity was implemented using a specific sequence: initial instructions by the intervention provider, running the activity by the students, interactive discussion and synthesis of the contents, delivery of summary sheets to the students.

Data Analysis

Preliminarily, descriptive statistics about gambling behavior were reported. Then, in order to evaluate the efficacy of the intervention, as a first step, we tested the baseline equivalence of the Training and No Training groups with independent samples *t*-tests considering cognitive distortions, gambling behavior, and gambling problems. As a second step, to analyze the efficacy of the intervention on gambling cognitions, a 2-way mixed ANOVA with Time (pre/post-test) as within factor and Group (Training/No Training) as between factor was conducted with the total score at the GRCS-RA and each subscale scores as dependent variables. Post hoc *t*-tests were subsequently conducted in order to analyze the significance and the direction of the detected changes from pre-test to post-test inside the Training group and the No Training group separately.

Results

As expected, there was a high prevalence of adolescent gamblers (75%) in the sample, and, among them, a high prevalence of adolescents at-risk for disordered gambling (16%) and with disordered gambling symptoms (10%). The most practiced activities were instant scratch cards (56%), sports bets (54%), and cards for money (40%). The versatility score had an average value of about three gambling activities in the year ($M = 2.91$, $SD = 2.54$). Adolescents resulted to gamble predominantly with friends (84%).

Preliminarily, we verified that the two groups were homogeneous at the pre-test concerning gambling-related cognitions. Non-significant differences were evidenced for the total score at the GRCS-RA and the three subscales (respectively, total score: $p = .102$; *Illusion of Control*: $p = .130$; *Predictive Control*: $p = .235$; *Interpretative Bias*: $p = .109$). Non-significant differences were also found for gambling behavior ($p = .341$) and disordered gambling symptoms ($p = .161$).

To verify the effects of the intervention on gambling cognitions, a 2-way mixed ANOVA with Time (pre/post-test) as within factor and Group (Training/No Training) as between factor was conducted with the total score at the GRCS-RA as the dependent variable. A significant Time × Group interaction was found (F (1,54) = 8.14, $p = .006$, $\eta^2_p = .170$). Post hoc *t*-tests showed the interaction effects to be due to significant changes from pre-test to post-test in the Training group but not in the No Training group. Specifically, in the Training group, there was a significant reduction of gambling-related cognitive distortions ($t(11) = 2.67$, $p = .022$) from pre-test ($M = 34.20$, $SD = 7.48$) to post-test ($M = 27.83$, $SD = 10.47$). This change was associated with a large effect size (Cohen's $d = 0.77$). No significant changes occurred in the No Training group ($t(44) = -1.40$, $p = 0.170$) from pre-test ($M = 30.07$, $SD = 9.35$) to post-test ($M = 32.07$, $SD = 10.95$) (Fig. 1).

To verify the effects of the intervention on the singles specific gambling cognitions, a 2-way mixed ANOVA with Time as within factor and Group as between factor was conducted with the scores of each subscale as the dependent variable. Results showed significant Time × Group interactions for the three subscales: *Illusion of Control* (F (1,54) = 3.56, $p = 0.05$, $\eta^2_p = 0.062$), *Predictive Control* (F (1,54) = 9.08, $p = 0.004$, $\eta^2_p = 0.144$), and *Interpretative Bias* (F (1,54) = 4.27, $p = 0.044$, $\eta^2_p = 0.073$). For each subscale, post hoc *t*-tests showed the interaction effects to be due to significant changes from pre-test to post-test in the Training group but not in the No Training group. Specifically, in the Training group, there was a significant reduction – large in size – of the three specific gambling-related cognitive distortions: *Illusion of Control* ($t(11) = 2.38$, $p = 0.036$, Cohen's $d = 0.69$; Mpre = 9.17, $SD = 2.33$; Mpost = 7.50, $SD = 3.23$); *Predictive Control* ($t(11) = 2.22$, $p = 0.049$, Cohen's $d = 0.64$; Mpre = 14.92, $SD = 3.89$; Mpost = 11.92, $SD = 4.32$); and *Interpretative Bias* ($t(11) = 2.27$, $p = 0.044$, Cohen's $d = 0.66$; Mpre = 10.42, $SD = 2.61$; Mpost = 8.42, $SD = 3.68$). Instead, no significant changes occurred in the No Training group for the thee

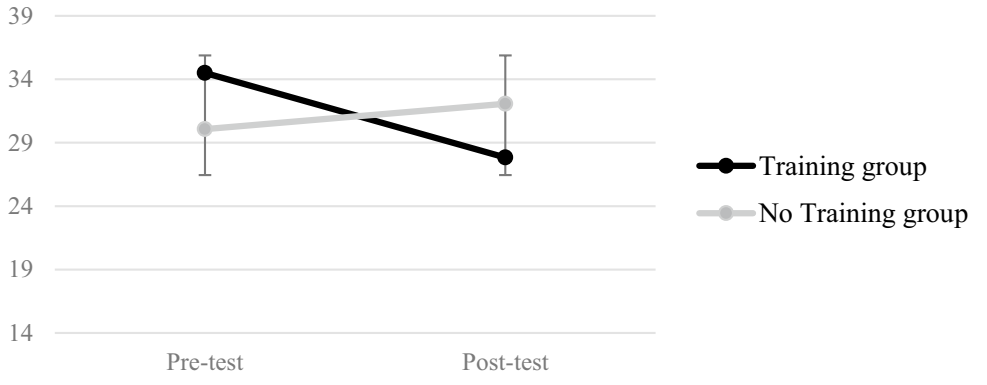

Fig. 1 Interaction effect between Time and Group on the Gambling Related Cognitions Scale – Revised for Adolescents

subscales: *Illusion of Control* ($t(43) = -0.85$, $p = 0.399$; Mpre = 7.91, $SD = 2.98$; Mpost = 8.39, $SD = 3.54$); *Predictive Control* ($t(43) = -1.73$, $p = 0.092$; Mpre = 13.18, $SD = 4.24$; Mpost = 14.20, $SD = 5.01$); and *Interpretative Bias* ($t(43) = 2.27$, $p = 0.396$; Mpre = 8.97, $SD = 3.36$; Mpost = 9.48, $SD = 3.60$).

Discussion and Conclusion

The aim of the present study was to verify the efficacy of a targeted preventive intervention in reducing gambling-related cognitive distortions, an important risk factor for maladaptive gambling behavior. In line with a recent study (Donati et al., 2018) based on the work of Toplak et al. (2007), we applied the dual-process model to explain and prevent gambling behavior in adolescents. Our intervention supports the results suggested by Clark (2010) that the high propensity for individuals in committing mistakes in reasoning and judgment makes them particularly vulnerable to adhere and maintain cognitive distortions related to gambling. In detail, our work showed that focusing on learning the concept of randomness is effective as a targeted prevention intervention as a significant reduction of the specific gambling-related cognitive distortions was obtained. Indeed, among adolescents who attended the training program, it was evidenced a significant reduction of cognitive distortions, specifically Illusion of Control, Predictive Control, and Interpretative Bias. Looking at the effect sizes of the changes obtained for distortions, we found a substantial equivalence of the reduction. This means that adolescents have decrease their view of being able to control gambling outcomes through personal actions or beliefs or through cues related to the gambling bets. Moreover, they reduced the tendency to wrongly attribute the cause of the losses and wins at gambling. This change may be attributed to the consolidated learning – through the intervention – about the role of randomness to determine the outcomes in gambling that may have consequently led adolescents to have more rational perception and beliefs about the role of personal control.

The strength of our results is that the evidence of the efficacy of the intervention has been obtained with adolescents with a high risk for gambling-distorted cognitions and gambling-related problems (Keen et al., 2017; Ladouceur et al., 2013). This is an important point as the majority of the interventions in the field of gambling can be classified as primary preventive programs (Huic et al., 2017), i.e., directed to all adolescents, regardless their risk for gambling problems.

The efficacy of this kind of educational approach further consolidates the adequacy of a cognitive-developmental framework of problem gambling prevention with youth (Keen et al., 2019). This kind of approach requires intervention providers to be experts with these concepts and to be good teachers as regards exposing and discussion of gambling-related misconceptions. Doing education about these contents requires the challenge of teaching the mathematical principles that underpin them. Research

that applies the conceptual change model to science education suggests misconceptions also facilitate learning new complex information, such as gambling-related mathematical concepts as randomness and statistics (Keen et al., 2019). Indeed, gambling misconceptions may result from a knowledge deficit of specific concepts in mathematics, including randomness, probabilities, and negative expected return (e.g., Toplak et al., 2007). Improving understanding of the mathematical underpinnings of commercial gambling products has been described as an important strategy to promote responsible attitudes toward gambling and prevent harm (Blaszczynski et al., 2015; Lowe & Money, 2017). For instance, necessary prerequisites to dismantle misconceptions like the gambler's fallacy involve education around concepts of independence and mathematical expectation (Peard, 2008).

It follows that educational and prevention programs in the field of adolescent gambling must be delivered by specialized and trained staff about mathematical and statistics prerequisites necessary to educate youth about gambling. More broadly speaking, this highlights the importance of training prevention program providers in order to develop preventive initiatives with a solid theoretical foundation and a great practical potential (Donati et al., 2022; Hall & Hord, 2001; Nation et al., 2003). Although the strengths, this study has some limitations to consider. First, as our work was conducted with a small sample of boys attending Italian public high school, caution has to be paid about the generalizability of the present results. It would be useful to test this dual-process approach in targeted prevention with other kinds of at-risk adolescent populations, such as drop-out adolescents, adolescents attending vocational training centers, and immigrant adolescents. Additionally, to reinforce these results, it would be necessary to verify the long-term effects of the intervention in terms of temporal stability of the short-term effects and changes on gambling behavior. Finally, as the intervention activities have a limited duration, in order to make the effects of intervention longer as much as possible, it would be useful that also school teachers also reinforce certain aspects related to probability even when the intervention is finished. In fact, probabilistic reasoning concerns various school disciplines and distinguishes scientific thought and method in general.

In sum, the efficacy of this intervention in reducing an important risk factor for maladaptive gambling behavior, i.e., gambling-erroneous cognitions, is very important as changing specific correlates of maladaptive gambling behavior may have effects that extend to other health behaviors (Hawkins et al., 2015).

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Declarations

Conflict of Interest The authors declare no competing interests.

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