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Research article

Hypnotizability-related risky experience and behavior

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ABSTRACT

Risk is the probability of an adverse event. The proneness to take a risk and the risk taking behavior differ among the general population.

Hypnotizability is a stable psychophysiological trait expressing the individual proneness to modify perception, memory and behavior following specific suggestions also in the ordinary state of consciousness. Some hypnotizability-related neurophysiological and behavioral correlates suggest that hypnotizability level, measured by standard scales classifying individuals as low (lows), medium (mediums) and high hypnotizable (highs) subjects, can be related to risk propensity and risk-taking. To study whether hypnotizability modulates risk propensity and behavior, we recruited healthy participants, classified through the Standford Hypnotic Susceptibility scale, form A, and compared lows' (n = 33), mediums' (n = 19) and highs'(n = 15) experiential and behavioral risk perception and propensity variables through the Domain-specific risk-taking scale and the Balloon Analogue Risk Task. MANOVA results indicated that different hypnotizability levels are not associated with different risky behavior and experience, except for higher expected financial benefits from risky behavior in lows. However, hypnotizability-related risk profiles were identified through correlational analyses. In fact, highs exhibited a negative association between risk perception and propensity to risk-taking, whereas mediums and lows displayed a positive association between risk propensity and expected benefit. In conclusion, the highs' profile indicates a more automatic behavior with respect to mediums and lows.

1. Introduction

Risk is the probability of an adverse event occurring multiplied by the severity of the impact [1]. The neural basis of risk behavior involves structures with opposing motivational components: the bilateral anterior insula promotes risk avoidance, while the ventral striatum is linked to reward and approach behavior [2,3]; the medial prefrontal cortex interacts with the posterior cingulate cortex, precuneus, dorsomedial PFC and amygdala bilaterally - contributing to the subjective emotional experience, social cognition and self-relevant information processing [4]. Striatal and cingulate risk-related activities increase the probability of a risky choice, while activation of the inferior frontal gyrus decreases it [5,6]. The activation of the anterior cingulate cortex is associated with changes in risk perception due to environmental context such as estimates of richness of alternatives, the value of alternative choices, the cost of foraging [7,8].

Original research highlighted the preeminent left and right/bilateral activation in correspondence of approaching and avoiding behavior, respectively [9]. A bilateral emotional model (frontal, orbitofrontal and insula), however, has been suggested for avoiding/approaching networks [10].

Individual risk propensity is considered a stable personality trait based on three main trait-like tendencies: sensation-seeking, impulsiveness, and adventurousness [11,12]. A high-risk propensity involves engaging in behaviors associated with a high probability of adverse outcomes [13]. Nevertheless, experimental evidence shows that risk-taking behavior is characterized by a large variability across situations. It is not stable over time and may differ among different areas, for instance financial or recreational [14–16]. Also, Risk-Taking Behavior (RTB) can be influenced by individual and situational factors, such as emotional states [17,18], sex and age, so that males and young people are more likely to take risks than females and the elderly [19,20].

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Hypnotizability is a stable psychophysiological trait expressing the individual proneness to modify perception and behavior following specific suggestions. Experiential and behavioral validated scales assess hypnotizability classifying individual as low (lows), medium (mediums) and high hypnotizable (highs) subjects [21,22]. Hypnotizability shows physiological correlates in the sensorimotor (i.e., postural/visuomotor control, motor cortex excitability, functional equivalence between imagination and perception/action), cardiovascular (post-occlusion flow-mediated dilation, cerebrovascular reactivity) and cognitive/emotional domain (attention stability, emotion intensity during imagery). These correlates can be observed also in the ordinary state of consciousness and in the absence of suggestions [23–27]. Neuroimaging studies showed reduced grey matter volume (GMV) of the left anterior/entire insula [28,29,30] and of the left cerebellar lobule IV-VI [29], whereas larger GMV was observed in the highs' mid-temporal and mid-occipital regions and in the left superior and medial frontal gyri, [28]. Stronger functional connectivity was found in highs between the dorsolateral prefrontal and the dorsal anterior/posterior cingulate cortex [28,31], as well as, between the posterior cingulate cortex and precuneus/ fronto-parietal network bilaterally, and between the executive-control network and a right postcentral/parietal area. Negative correlations of hypnotizability-related functional connectivity were found between the right fronto-parietal network and the right lateral thalamus [28,30].

The highs' reduced insula GMV and their stronger functional connectivity between the executive network and the cingulate cortex may relate to risky behavior. Another link between risk-taking behavior and hypnotizability could depend on hypnotizability-related emotional regulation, as highs report higher psychological well-being than lows, suggesting more adaptive emotional regulation [32,33]. Also, they show more automatic behaviors, faster reaction times, and a present-focused orientation due to their absorption abilities [34–40].

Both highs and lows tend to avoid unpleasant and anxiogenic situations less than mediums [41,42], which suggests that both groups may exhibit high propensity to RTB. Nonetheless, the highs' insula GMV is reduced with respect to lows' [28–30] but it was not compared to the mediums'. Indeed, more fine-grained differences in risky behavior between highs, lows and mediums can be expected.

However, based on the highs' smaller insula GMV and less accurate interoception with respect to lows [29,43] we expect that they are less sensitive than lows to the experience of risk, as evaluated by the Domain-Specific Risk-Taking (DOSPERT) questionnaire [16]. Based on their lower tendency to avoid potentially unpleasant behavior/experience with respect to mediums (but not to lows), we expect that highs and lows may be exhibit greater propensity than mediums to risk taking, as assessed by Balloon Analog Risk Test (BART) [44]. The absence of mediums in imaging studies [28,29], and the similar lower tendency of highs and lows to avoid potentially unpleasant situations with respect to mediums [42], however, make these predictions weak. Thus, the aims of the study were to compare the three groups on DOSPERT and BART features to characterize groups profiles based on the correlations between DOSPERT domains and the possible associations between DOSPERT and BART scores.

2. Methods

The study has been carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans and has been conducted after the approval of the Ethical Committee of the University of Pisa n. 8/2021. All participants provided an informed consent.

2.1. Participants

A sample of participants who had previously participated in an experimental session in which they had been submitted to hypnotic assessment through the Italian version of the Stanford Hypnotic Susceptibility Scale, Form A (SHSS) measuring their hypnotizability [45] were contacted by telephone and invited to participate in the experimental session. Participants were asked to provide demographic information (age, sex) and other relevant information for inclusion and exclusion criteria (e.g. neurological/psychiatric diseases, sleep disorders, drug intake).

According to G*power analysis [47] for mixed MANOVA (3 groups x 2 sexes x 8 DOSPERT scales) the minimum number of participants required to obtain $\alpha = 0.05$ and $1\text{-}\beta = 80$ % was 64 for DOSPERT questionnaire and 47 for BART test (3 groups x 2 Sexes x 3 tasks).

Sixty-seven healthy participants of both sexes (females: 45, males: 22), aged between 18 and 35 years, were recruited among the students at the University of Pisa. None of them reported neurological/psychiatric diseases, drug intake or sleep disorders. According to their hypnotizability scores they were divided into three groups: poorly (lows, SHSS: 0–4, n = 33, 19 females), medium (mediums, SHSS: 5–7, n = 19; 15 females) and highly hypnotizables (highs, SHSS: 8–12, n = 15, 11 females).

2.2. Experimental procedure

Experimental sessions were performed between 10:00 AM and 4:30 PM. The procedure included experiential (DOSPERT scale) and behavioral tests (BART) performed on a computer in a sound-attenuated room. They completed the Italian version of the DOSPERT scale [46]- whose reliability and validity have been assessed - and performed the BART [37].

2.2.1. Domain-specific risk-taking scale

We used the validated Italian version of the DOSPERT scale. It consists of 30 items in the form of statements describing a risky behavior, and for each of them the participant is asked to express on a 1–7 Likert scale how likely it would be to engage in the described behavior (Probability of risk-taking) (1, really unlikely; 7, very probable), how risky it is considered (Risk Perception) (1, not at all risky; 7, really risky) and, how much potential benefit could he/she have obtained from each presented situation (Expected Benefit) (1, no benefit; 7, many benefits). The DOSPERT Scale evaluates Probability of risk-taking, Risk Perception and Expected Benefit in five different domains of life (ethical, financial, health/safety, social and recreational risks).

2.2.2. Balloon analogue risk task

The test consists of 90 trials. One out of three types of balloons, differentiated by the color (orange, yellow, blue), appears on the screen at the beginning of each trial. Each time the participant presses a key, the balloon will inflate allowing for a gain of 1 euro. This money is accumulated with each inflation in a temporary deposit. The balloon, however, at a certain point can explode, and the money temporarily banked is lost. At any time, the participant can choose whether to move the money accumulated up to that moment in a permanent "bank", thus keeping the earnings safe, or to continue inflating the balloon to increase the profit, risking, however, that it explodes losing all the money earned during that trial. Each color has different probabilities of exploding, but participants were not given any information about color coding. According to a specific algorithm, the average breaking point for the blue balloon is 64, while for the yellow and orange balloon is 16 and 4, respectively. The average number of inflations of the unburst blue balloons represents the best indicator of individual variability in the performance of this test and therefore is taken as an indicator of risk propensity.

The variables measured in this task are: *Pumps type 3*, i.e. how many times the button is pressed to inflate the blue balloon (type 3 stands for the blue balloon); *Pumps prior to recruit*, i.e. how many times the participants click to inflate the balloon before collecting the money; *Total time* spent performing the task. It is worth highlighting that, although the authors of the test validation document [44] recommend using the number of clicks of unexploded blue balloons as the main test metric, they report similar results with the metrics we choose as main variables.

2.3. Statistical analysis

Prior to analyses the normality of observed DOSPERT and BART distributions was determined by the Kolmogorov-Smirnov test. Parametric analyses were conducted using IBM SPSS Statistics.20. The internal consistency of the DOSPERT scale was ascertained by Cronbach' alpha coefficient (α = 0.624). The DOSPERT scale dimensions were analysed through MANOVA with Group (highs, mediums, lows) and Sex (males, females) as independent variables, and Domains (*probability of risk-taking, risk perception, expected benefits* in the *ethical, financial, health, recreational, social* domains) as dependent variables. Given the absence of differences between groups in each dimension, except for *financial benefit*, the total values of DOSPERT subscales were studied by 3 groups x 3 subscales (total *expected benefit,* total *risk perception,* total *probability of risk taking*) design.

The BART variables scores (*Pumps Type3, Pumps prior to recircuit, Time*) were analysed through separate univariate ANOVAs with Group (high, medium, low) and Sex (males, females) as independent variables.

Also, we studied the correlations (Pearson coefficient) between the DOSPERT scales total values (sum of the scores in all the domains), and between the DOSPERT and BART variables in each group to characterize the risk-related profile of each group.

3. Results

3.1. DOSPERT scale

No significant group effect was found for total *expected benefit, risk perception* and *probability of risk-taking*. However, a significant hypnotizability effect was found for the *expected financial benefit* (F (2, 66) = 4.21, p =.019, η^2 = 0.121, α = 0.841), with higher scores in lows than in mediums (p =.007) and no difference between highs and mediums/lows (Table 1).

Multivariate analysis on DOSPERT scales yielded a significant Sex effect (F (2, 66) = 2.065, p =.030, η^2 = 0.397, α = 0.910) with higher scores in males than in females in *health risk perception* (F (1,66) = 8.62, p =.005, η^2 = 0.124, α = 0.824).

3.2. BART task

Separate univariate ANOVAs on the selected BART variables revealed no significant difference in *Pumps Type3, Pumps prior to recruit, Time* (Table 1).

3.3. Groups profiles

Correlation analysis within groups revealed that the associations between the total scores of *expected benefit, risk perception* and *probability of risk-taking* were different in the three hypnotizability groups. In fact, a significant negative correlation between total *risk perception* and *risk-taking* was found only in highs (r= - 0.655, p =.009) (Fig. 1).

In contrast, total *expected benefit* was positively correlated (r = 0.423, p =.014) to *risk-taking* in lows, to *risk perception* (r = 0.472, p =.041, not surviving to Bonferroni correction with p =.016) and *risk-taking* (r = 0.628, p =.004) in mediums, while no correlation was observed in highs (Fig. 2).

No significant correlations were found between DOSPERT and BART items in lows, mediums and highs, as the highs' correlation between total benefit and time (r = 0.557, p =.031) did not survive to Bonferroni correction (p =.016).

4. Discussion

MANOVA applied to the mean values of DOSPERT and BART variables did not support the hypothesis that highs, mediums and lows may be differentially prone to take a risk and to behave accordingly. No differences between hypnotizability groups were found, in fact, in both risk perception (DOSPERT) and risk-taking behavior (BART). The use of the total values of DOSPERT variables (expected benefit, risk perception, risk taking) was suggested by studies which identified general risk related factors together with specific domains [48].

The absence of hypnotizability-related differences indicate that the variants of the insula GMV (reduced volume in highs than in lows) [28–30], the different tendency to avoid potentially unpleasant situations (lower in highs and lows with respect to mediums) and the different emotional regulation [42] as well as the different level of wellbeing (higher in highs than in lows, with mediums exhibiting intermediate values [32], apparently do not induce hypnotizability-related differences in risk experience and behavior.

Table 1
DOSPERT Scale and BART tasks (mean, SD).

		lows		mediums		highs	
DOSPERT subscales	Domains	mean	SD	mean	SD	mean	SD
Expected benefit	*ethical*	15.42	5.73	14.42	3.75	13.13	4.41
	financial	21.27	6.25	16.11	5.03	18.6	4.00
	health	12.09	3.78	13.58	4.14	10.93	2.46
	recreational	21.73	6.09	24.26	8.81	23.87	5.68
	social	29.52	4.44	28.74	4.01	30.00	3.66
	total	100.03	16.07	97.11	18.58	96.53	14.93
Risk perception	*ethical*	27.48	4.99	24.53	5.91	28.2	5.92
	financial	27.24	6.07	26.47	6.75	27.47	6.09
	health	31.73	5.71	31.21	5.46	31.07	5.36
	recreational	27.91	6.46	27.21	5.69	27.8	5.76
	social	19.03	4.14	19.26	6.10	17.13	3.87
	total	133.39	18.57	128.68	19.27	131.67	18.88
Risk-taking probability	*ethical*	12.76	4.87	12.95	3.79	12.4	2.82
	financial	15.24	4.60	13.16	4.34	14.27	3.71
	health	17.61	5.86	17.74	5.76	18.8	4.93
	recreational	22.00	7.43	21.05	6.70	22.07	5.61
	social	30.15	5.06	30.42	4.78	31.73	4.99
	total	97.76	15.71	95.32	13.25	99.27	10.64
BART variables							
Pumps type 3		17.07	13.14	16.01	12.48	18.76	13.84
Pumps prior to recircuit		11.35	8.02	10.03	6.70	10.50	6.56
Time (sec)		409	163	426	103	412	149

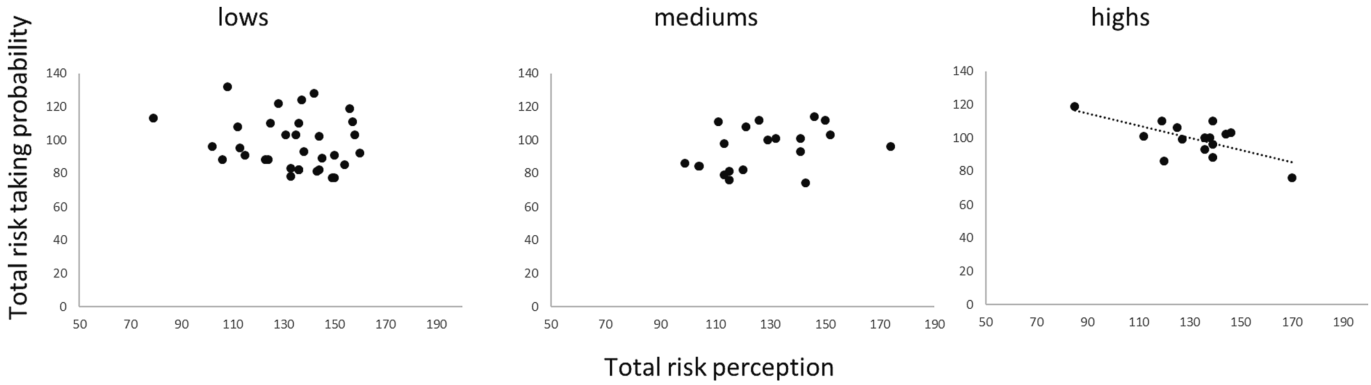

Fig. 1. Correlation between the DOSPERT subscales Risk perception and Probability of risk-taking. The association between total Risk perception and total Probability of risk-taking values in lows, mediums, highs, are shown. The trendline indicate the significant correlation (Pearson correlation) in highs.

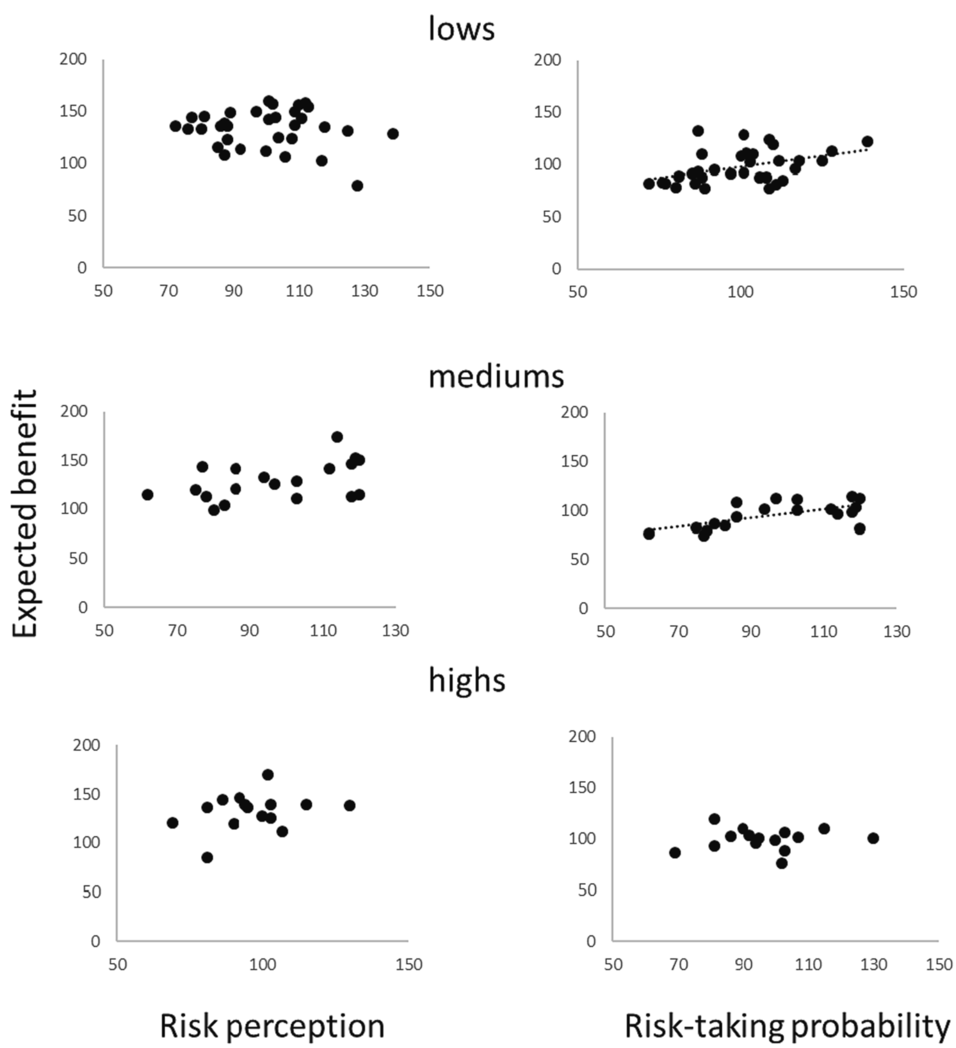

Fig. 2. Correlation between the DOSPERT subscale Expected benefit and the subscales Risk perception and Probability of risk-taking. The association between total Expected benefit values and both total Risk perception and total Probability of risk-taking values in lows, mediums, highs, are shown. Trendlines indicate the significant correlations (Pearson correlation).

The reasons possibly accounting for the present negative results could be, on the one hand, the large variability of risky behavior among the general population, as some individuals among the general population, in fact, display trait risk proneness, while others are more sensitive to situational variables [16]. Other sources of variability regarding all groups are individual traits such as the locus of control, and the proneness to possible learning of risk behavior throughout the lifetime, depending, for instance, on different abilities of emotional reappraisal [18]. On the other hand, among highs, there are different *hypnotic* profiles, which may indicate preferential motor inhibition, or hallucination production or dissociation ability [41], or greater tendency to fantasize or to dissociate [49].

Only the *financial benefit* domain distinguished the groups, and it has been described as the most sensitive to a general, rather than specific risk factor [48]. Its score, higher in lows than in mediums, with highs' values non significantly different from both, is interesting, although lows represent 15 % of the general population [45], and we may argue that this aspect of risk behavior may not be very relevant to the behavior of most persons.

Despite the similar scores obtained at DOSPERT scale and BART task by highs, mediums and lows, the groups profiles are different. The highs' greater emotionality [50,51] might have been buffered by their high wellbeing, facilitating automatic responses to the actual risk perception. In contrast to mediums and lows, in fact, highs exhibit a significant negative correlation between the total scores of risk perception and risk-taking, whereas in the other two groups the higher the potential benefit the higher risk-taking.

The relevance of expected benefits is confirmed in lows by their significant difference in financial expected benefit with respect to mediums. Financial decisions and assessments of associated risks are in many ways no different from other types of decisions [52]. Nonetheless, they do not involve personal danger, do not refer to any primary reward, such as food, drink or sex, and can be strongly conditioned by educational and situational variables [53].

Risk experience, indicated by DOSPERT scale, and risky behavior, indicated by BART test, are independent from each other in all groups, and, in fact, a correlation between them was not necessarily expected. Emotional traits and states could influence them differentially 18[24], and behavioural measures – like the BART test- might reflect transient states rather than trait characteristics better measured by DOSPERT questionnaire [54].

The sex difference on the DOSPERT scale was expected and is supported by present findings. In fact, previous research based on self-reported *risk taking* [16,55] indicated that women, compared to men, generally consider potentially dangerous activities riskier than men and expect fewer benefits from participating in these activities. Nonetheless, situations in which females exhibit riskier behavior than males have been also reported [20].

A general limitation of the present study is the view that BART test is an indicator of decision making under uncertainty rather than under risk conditions [56]. Nonetheless, across the task all participants become progressively aware of the different probability of explosion of the red, blue, and yellow balloon. Although BART is a validated test [44], the number of inflations of the blue balloons may have been biased by colours. In general, in fact, blue is associated with a sense of security/stability and encourages intellectual activity, reason and logical thinking, while orange or red can induce "fight or flight" reactions [57].

5. Conclusions

The reported findings contribute to the field of hypnotizability by showing that high hypnotizability does not predict perception and behavior in conditions of risk-related decision making. The variability in the highs' cognitive characteristics [58,49] might have contributed to this negative finding. However, different risk related profiles have been identified, in that highs exhibit a negative association between *risk perception* and *risk taking,* likely due to their typical automatic behavior [59], whereas mediums and lows display proneness to *risk taking* positively associated with *potential benefit* suggesting less automatic mechanisms of choice.

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CRediT authorship contribution statement

Francy Cruz-Sanabria: Writing – review & editing, Methodology, Formal analysis. **Ugo Faraguna:** Writing – review & editing, Funding acquisition. **Carola Panu:** Investigation. **Leonardo Tommasi:** Investigation. **Simone Bruno:** Writing – review & editing, Methodology. **Andrea Bazzani:** Writing – review & editing, Methodology. **Laura Sebastiani:** Writing – review & editing, Writing – original draft, Supervision, Formal analysis, Conceptualization. **Enrica L. Santarcangelo:** Writing – review & editing, Writing – original draft, Supervision, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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