



## Impaired decision-making in child sexual offenders: Findings and prospects

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### ARTICLE INFO

#### Keywords:

Child sexual abuse  
Decision making  
Cognitive modelling  
Reward processing

### ABSTRACT

**Objective:** Regarding the impairments in decision-making strategies as a predisposing factor to adverse behaviours and sexual violence, we hypothesize impairments on decision-making processes in Child Sexual Offenders (CSO) population. The aim of this study was to highlight these alterations and characterize them.

**Methods:** We compared decision-making processes between sixty-four convicted CSO and sixty-four matched subjects without criminal history, using the Iowa Gambling Task (IGT). A Bayesian computational model (ORL) was applied to assess different components of decision-making: reward learning, punishment learning, forgetfulness, win perseverance and deck perseverance.

**Results:** Respecting the underlying processes of the IGT task, the ORL model revealed that reward learning (95% HDI [-0.299, -0.099]) and punishment learning were lower in CSO compared to controls (95% HDI [-0.054, -0.021]), while forgetfulness (95% HDI [0.168, 0.877]) and deck perseverance (95% HDI [0.659, 4.478]) were higher.

**Conclusions:** CSO display impairments in decision-making strategies in learning processes related to reward or punishment, and seem less prone to make long-term strategies with a strong preference toward perseverance. These findings have important potential applications for future research on sexual violence, management of CSOs cognitive vulnerabilities and adjusting strategies to reduce the risk of recidivism. Trial Registration: ID-RCB 2011-A00402-39.

### 1. Introduction

Sexual offending is a major public health issue (Barth et al) and one of the main contributors to the global burden of disease (Mathers and Mascarenhas, 2009), particularly when experienced in childhood and when it affects sexuality (Maniglio, 2009). The effects of victimization contribute significantly to the emergence of both psychiatric and somatic disorders (Hailes et al., 2019). The reduction of sexual violence requires an understanding of the mechanisms underlying aggression and the study of offenders, especially when they present a psychiatric disorder.

The stress-diathesis model in Child Sexual Offenders (CSO) (Mitchell and Beech, 2011; Ward and Beech, 2006) suggests some alterations in

serotonergic activity and cognitive control provided by the pre-frontal cortex (PFC). Disturbances in the serotonergic system are strongly associated with violent behavior (Seo et al., 2008) but also with paraphilic disorders (Kafka, 2003). The PFC organizes the behaviors and regulations of action under the impulse of the orbitofrontal cortex (OFC), a social, emotional and sexual motivational pivot with its serotonergic projections.

Many studies have highlighted structural or functional alterations of these brain areas in psychiatric or criminal populations (Darby et al., 2018; Sajous et al., 2020) and their neuropsychological involvement in decision-making strategies (Bechara, 2001; Bechara et al., 1999, 2000). While decision-making deficit appears to be a transnosographic trait that modulates the risk for violence (Bechara and Damasio, 2005;

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<https://doi.org/10.1016/j.jpsychires.2024.12.035>

Received 3 September 2023; Received in revised form 6 September 2024; Accepted 21 December 2024

Available online 24 December 2024

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Jollant et al., 2007), only few studies have been conducted on CSO population showing impairment of executive functions (Rodriguez et al., 2017) and response inhibition (Turner et al., 2018). Furthermore, the Iowa Gambling Task (IGT) is the most widely complex decision-making task used in previous studies to explore decision-making within healthy and psychiatric populations (Best et al.). It is a decision-making task with monetary feedback after each choice. This feedback should allow participants to learn which choices are safe (i.e. larger wins than losses) and risky (i.e. larger losses than wins) for earning money during 100 trials. IGT is a decision-making task under conditions of uncertainty and risk, that involves value-based learning and presents two degrees of uncertainty: an ambiguous phase when subjects cannot estimate the outcome (first 40 trials), and a risky phase when subjects can better estimate the possible outcome (last 60 trials). Originally founded to detect damage in prefrontal brain regions, IGT has been gradually used to discriminate a variety of decision-making deficits thanks to multiple computational models (Busemeyer and Stout, 2002). These models decompose the neurocognitive process into its constituent parts and allow exploring some consistent trends in IGT behavioral data (long-term expecting value, gain-loss, frequency, perseverance, reversal-learning). Since the apparition of the Expectancy-Valence Learning Model (EVL) (Busemeyer and Stout, 2002) and its evolution the Prospect Valence Learning (PVL), several computational models compete to capture participant's decision-making performance more accurately (Ahn et al., 2014). The best compromise between competing models to date seems to be offered by the Outcome-Representation Learning (ORL) model (Haines et al., 2018). The ORL model provides parameters related to feedback (reward learning, punishment learning), learning (forgetfulness) and perseverance in choices (win perseverance, deck perseverance) to explain decision making.

Therefore, to improve the understanding of child sexual abuse behaviors and to identify potential therapeutic targets in CSOs, we studied decision-making strategies in a population of men convicted of child sexual abuse using the IGT. In order to specify the underlying processes of decision-making, we used the ORL model, which allows studying the latent variables during decision making and discriminating subdomains particularly relevant within our study population. We hypothesize that CSOs present, in comparison with a control population, some decision-making impairment such as punishment learning impairment and a tendency to persevere in unfavorable choices.

## 2. Methods

This is a cross-sectional observational multicentric pilot study, supported by the Montpellier University Hospital and approved by ethics committee (ID-RCB 2011-A00402-39). Inclusion for CSOs were conducted by the consultations at the Resource Centers for People working with Sex Offenders (RCPSOs) (Miele et al., 2014) at five sites in the South of France: three prison sites (Montpellier, Perpignan, and Muret) and two hospitals (Montpellier and Perpignan). The non-pedophile volunteers were recruited by the Montpellier Clinical Investigation Center. Adequate protections have been placed to ensure patient confidentiality (anonymity and data protection).

### 2.1. Participants

A total of 64 male (assigned sex at birth and gender identity) volunteers (age, mean  $\pm$  SE = 49.60  $\pm$  1.45) convicted for child sexual offences and who have admitted the offense (rapists, child molesters, child abuse material offenders) were recruited through three Resource Centers for People Working with Sex Offenders (RCPWSOs) across Occitanie, a French region located in the south of France. We use the term "Individuals who Sexually Offended Children" (ISOCs) in this article assuming that the subjects of the sample matched for three cumulative conditions: they have committed at least one Child Sexual Offense + they have been definitively convicted of this offense at the

time of the study + they have confessed to the assault, even if they may deny responsibility. All ISOCs were informed that all study data will remain confidential and will be stored anonymously, and that their participation could not have any consequence regarding the end of their sentence (sentence remission or adjustments). They had no economic compensation.

A community sample of 64 teleiophiles men (age, mean  $\pm$  SE = 48.43  $\pm$  1.49) with no previous convictions or legal proceedings, matching for sex, age and educational achievement, has been recruited in the Clinical Center of Investigation of Montpellier. They had economic compensation.

Inclusion criteria for all study subjects were as follows: male, aged 18 to 65, agreement to cooperate with clinical and neuropsychological evaluations, and written informed consent after a full explanation of the procedure and a cooling-off period of at least 7 days.

The exclusion criteria were: existence of a current major depressive episode, history of cerebral neurological disorder or head trauma, previous use of the IGT test, existence of a current or past psychotic disorder, recent intake (24 h) of a psychoactive substance. Written informed consent was obtained from all participants after the procedure had been fully explained. Because data collection of four subjects were corrupted, our final analysis was based on 63 sexual offenders, and 61 paired controls.

### 2.2. Procedure and clinical assessment

The study was presented to the ISCO and to a community sample and those who matched with the inclusion criteria and agreed were included. Participants were interviewed by a senior psychiatrist to evaluate socio-demographic information, current addiction and psychotropic treatments, current and past psychiatric disorders according to the DSM-IV criteria using the French version of the Mini International Neuropsychiatric Interview (MINI 5.0) (Sheehan et al., 1998) and depressive symptomatology using the Montgomery-Åsberg Depression Rating Scale (Montgomery and Åsberg, 1979). Previous suicide attempts were recorded with the MINI, but assigned according to the violence and their occurrence, between violent and non-violent attempts. Violent suicide attempts involved hanging, gunshot wounds, jumping from heights, deep cutting and drowning. A criminal history of sexual offenders was completed by the penitentiary administration (criminal history, number and type of assaults, age and relationship to victims).

After the interview, participants completed the Wechsler Adult Intelligence Scale 4th Edition (Coalson et al., 2010) to obtain total IQ and, subsequently, participants completed a computerized version of the IGT.

### 2.3. The Iowa Gambling Task

The Iowa Gambling Task (Bechara et al., 1994) evaluates decision-making under uncertainty. Participants are instructed to gain as much money as possible starting from 2000 € choosing 100 times from four different decks. After each trial, the software provides monetary feedback to the participants. There are two disadvantageous decks that provide high short-term rewards, but great punishments giving long-term losses (Decks A and B), and two advantageous decks that provide lower short-term rewards but also low punishments giving long-term gains (Decks C and D). Decks A and C provide moderate wins and losses (50 % of times give punishments) and decks B and D provided high percentage (90 %) of small losses and low percentage (10 %) of great punishments. IGT performance was determined using the Iowa Gambling (IG) index, as the difference between the number of trials with a card chosen from the advantageous decks minus the number of trials with a card chosen from the disadvantageous decks (CD – AB). The IG index is calculated for blocks of 20 trials, to determine whether participants show progressive learning during the task. The IG index for the first 40 trials that represent decision-making in conditions of ambiguity uncertainty (IG ambiguity) and for the 41–100 trials that represent

decision-making in conditions of risk uncertainty (IG risk). Finally, a total net IG index (all 100 trials) was also calculated.

#### 2.4. The outcome representation learning model

The ORL (Haines et al., 2018) is a reinforcement model used to decompose decision-making of IGT into five parameters: i) reward learning ( $A_{rew}$ ; from 0 to 1), higher values of this parameter represent faster reward outcome learning; ii) punishment learning ( $A_{pun}$ ; from 0 to 1), higher values of this parameter represent faster learning about punishment outcomes; iii) perseverance decay or forgetfulness ( $K$ ; from 0 to 242) is a decay parameter and represents how quickly people forget their past deck choices, higher values represent relatively short-term memories and lower values represent long-term memories of their own choices; iv) perseverance in wins ( $B_F$ ; from  $-\infty$  to  $+\infty$ ), the mostly negative values of this parameter (below 0) indicate greater perseverance for decks with a low win frequency (Decks A and C), while mostly positive values (above 0) indicate greater preference for decks with a high win frequency (Decks B and D); finally, v) deck perseverance ( $B_P$ ; from  $-\infty$  to  $+\infty$ ), the mostly negative results of this parameter (below 0) imply a preference for more random responses (switching decks), and the mostly positive results (above 0) imply a perseverance for choosing from the same deck.

#### 2.5. Statistical analyses

We applied Chi-square test (for qualitative variables) and Student's t-test (for quantitative variables) to determine if there were differences between groups in socio-demographic and clinical variables.

To analyze performance on the IGT, a MANCOVA was used with each block of the IG index as the dependent variable, the intra-group factor Block (Block 1 to Block 5), the inter-group factor Group (Sexual offenders/Control) and the Block\*Group interaction. Then, one-way ANCOVA was used with the net score as dependent variable and Group as independent variable. We adjusted all these analyses for educational achievement, current depression symptomatology and psychotropic medication intake. Post-hoc comparisons of degrees of freedom were adjusted based on Bonferroni correction.

As no previous study using computational models has been conducted on the IGT performance of sexual offenders, we first compared three of the most common computational models available in the hBayes DM package using Hierarchical Bayesian Analysis (HBA) (Ahn et al., 2017), in order to determine if the ORL model has the best fit. The three models were: the "Prospect-Learning Valence with the Decay rule" (PVL-D) model, the "Value-Plus-Perseverance" (VPP) model and the ORL model. To perform HBA, we used the R package hBayes DM with RStan 2.19.3 for sampling the posterior distribution. The Markov Chain Monte Carlo (MCMC) sampling algorithm used by Stan is the Hamiltonian Monte Carlo (HMC). A total of 10.000 samples were used after 15.000 burn-in samples were obtained for four chains ( $10.000 \times 4$  chains = a total of 40.000 samples; with 60.000 burn-in samples) for each model. For each parameter, the Gelman-Rubin test (Gelman and Rubin, 1992) was used in order to check the convergence of the chains (aka.  $\hat{R}$ ). All model parameters had  $\hat{R}$  values of 1.00; here  $\hat{R}$  values close to 1.00 indicate that the MCMC chains converge to the target distribution. We also performed a visual inspection of the chains in order to corroborate convergence to the target distribution. Model comparison was performed using the leave-one-out information criterion (LOOIC), to determine the model with the best fit to the data (Vehtari et al., 2017), the lower LOOIC was the model with better fit. Parameters for the best-fitting model were estimated for each individual to compare the sexual offenders and control groups. The posterior distribution mean and standard deviation of the parameters were calculated for each group. We used the posterior highest density interval (HDI), which is the range of parameter values having higher probability to be at 95%, in order to make decisions regarding the group comparisons. If the HDI

posteriors exclude 0, the comparison is considered significant. Pearson correlations between parameters, IGT net score and IGT compression were performed. All statistical analyses were performed using R 3.4.2 software.

### 3. Results

#### 3.1. Demographic and clinical variables

Comparison of the demographic and clinical characteristics (Table 1) reveal that Individuals who Sexually Offended Children (ISOCs) had higher educational achievement ( $t_{115,7} = -2.24, p < .027$ ), were more prone to have been divorced, separated or widowed ( $X^2 = 18.19, p < .001$ ) and being current tobacco smokers ( $X^2 = 4.94, p < .026$ ), compared to controls. In comparison to controls, sexual offenders reported more often a past major depressive episode ( $X^2 = 8.05, p < .005$ ) and a past suicide attempt ( $X^2 = 20.03, p < .001$ ). Moreover, ISOCs were more prone to use psychotropic medication currently ( $X^2 = 31.69, p < .001$ ) and report higher levels of current depressive symptomatology ( $t_{107,1} = -5.58, p < .001$ ), than controls. The other demographic, clinical variables and IQ score show do not significant differences between groups (all  $p > .050$ ).

**Table 1**  
Descriptive characteristics of the sample.

	Sexual offenders	Not offenders	<i>p</i> value
N =	63	61	
<i>Sociodemographic</i>			
Age	49.60 ± 1.45	48.43 ± 1.49	<i>p</i> < .574
<b>Study level</b>	12.79 ± 0.29	11.98 ± 0.22	<i>p</i> < .027
Sep./Div./Wid., n (%)	32 (50.8 %)	9 (14.8 %)	<i>p</i> < .001
Unemployed, n (%)	4 (6.3 %)	8 (13.1 %)	<i>p</i> < .203
Current smoker, n (%)	32 (50.8 %)	19 (31.1 %)	<i>p</i> < .026
<i>Psychiatric status</i>			
Lifetime major depressive episode, n (%)	31 (49.2 %)	15 (24.6 %)	<i>p</i> < .005
Lifetime mania/hypomania episode, n (%)	4 (6.3 %)	4 (6.6 %)	<i>p</i> < .962
<b>Depressive symptomatology</b>	7.57 ± 0.79	2.28 ± 0.52	<i>p</i> < .001
Current anxiety disorder, n (%)	11 (17.5 %)	5 (8.2 %)	<i>p</i> < .124
Current alcohol dep/abu, n (%)	1 (1.6 %)	1 (1.6 %)	<i>p</i> < .982
Lifetime suicide attempt, n (%)	24 (38.1 %)	3 (4.9 %)	<i>p</i> < .001
Violent suicide, n (%)	13 (10.5 %)	0 (0 %)	-
<b>Psycholeptic intake, n (%)</b>	28 (44.4 %)	1 (1.6 %)	<i>p</i> < .001
<i>Criminal history</i>			
Multiple victims, n (%)	35 (28.2 %)	-	-
Intra-family, n (%)	25 (39.7 %)	-	-
Extra-family, n (%)	27 (42.9 %)	-	-
Mixed, n (%)	11 (17.5 %)	-	-
<i>IQ and decision making</i>			
Total IQ	98.32 ± 1.63	100.92 ± 1.73	<i>p</i> < .277
IGT limited understood, n (%)	29 (46.0 %)	20 (32.8 %)	<i>p</i> < .275
IGT understood, n (%)	12 (19.0 %)	12 (19.7 %)	

Note: Sep./Div./Wid. = Separated, divorced or widowed; dep/abu = dependence or abuse; IGT = Iowa Gambling Task.

### 3.2. IGT behavioral results

Results for the IGT learning curve showed a significant Block\*Group interaction ( $F_{4,115} = 4.45, p < .002, \eta^2 = 0.13, \text{power} = 0.93$ ). *Post-hoc* comparisons showed that sexual offenders had significantly lower IG in block 4 than controls ( $F_{1,118} = 4.46, p < .037$ ). But as a significant trend, ISOCs had higher IG in block 5 than controls ( $F_{1,118} = 3.73, p < .056$ ) (Fig. 1).

### 3.3. IGT computational models

ORL showed the lower LOOIC, therefore it was the model with better fit for the sample, compared with PVL and VPP (Table 2). Thus, we used the ORL model to examine group differences in the parameters of interest.

After sampling the posterior distributions, comparison between sexual offenders and control groups (Table 3) indicate that ISOCs had significantly lower values in the reward learning parameter ( $A_{rew}$ ) (95% HDI = - 0.299, - 0.099; online Supplementary Fig. 1 shows the 95% HDI of group comparisons) and in the punishment learning parameter ( $A_{pun}$ ) (95% HDI = - 0.054, - 0.021) than control group, indicating that ISOCs have a slower learning capacity concerning feedback contingencies. Conversely, Individuals who Sexually Offended Children had significantly higher values for forgetfulness ( $K$ ) (95% HDI = 0.168, 0.877) and perseverance in decks ( $B_p$ ) (95% HDI = 0.659, 4.478) than the control group, indicating that ISOCs have short-term memories about their choices and persevere in the same deck. Fig. 2 shows the posterior distributions of the five parameters in each group.

Correlations between parameters and IGT behavioral performance (Supplementary Table 1) showed a significant positive correlation between punishment learning ( $A_{pun}$ ) and the IGT net score ( $r = 0.396, p < .001$ ) and a significant negative correlation between reward learning ( $A_{rew}$ ) and net score ( $r = - 0.434, p < .001$ ). Moreover, punishment learning ( $A_{pun}$ ) and perseverance in decks ( $B_p$ ) were positively related with IGT compression (respectively:  $r = 0.293, p < .001$ ;  $r = 0.247, p < .006$ ).

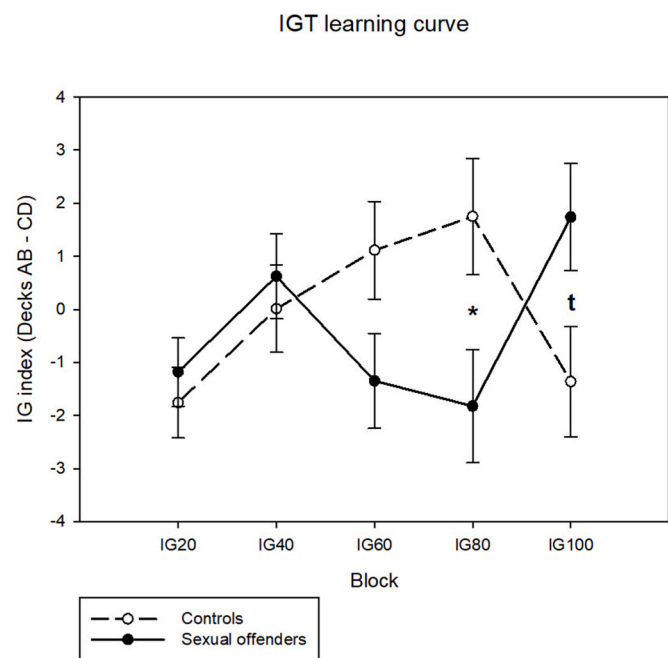


Fig. 1. IG index of the five blocks of 20 trials/each (mean ± SEM) for the two groups: Note: \* =  $p < .050$ ;  $t = p < .070$ .

Table 2

Post-hoc model fits.

	LOOIC
Prospect-Learning Valence Decay (PVL-D)	31821.08
Value-Plus-Perseverance (VPP)	29864.86
Outcome-representation learning (ORL)	29671.08

Note: LOOIC = leave-one-out information criterion.

Table 3

Values (mean ± SD) of the ORL model components from the posterior distributions of the Outcome-representation learning model scores in the two groups and the 95% HDI for the mean differences between groups.

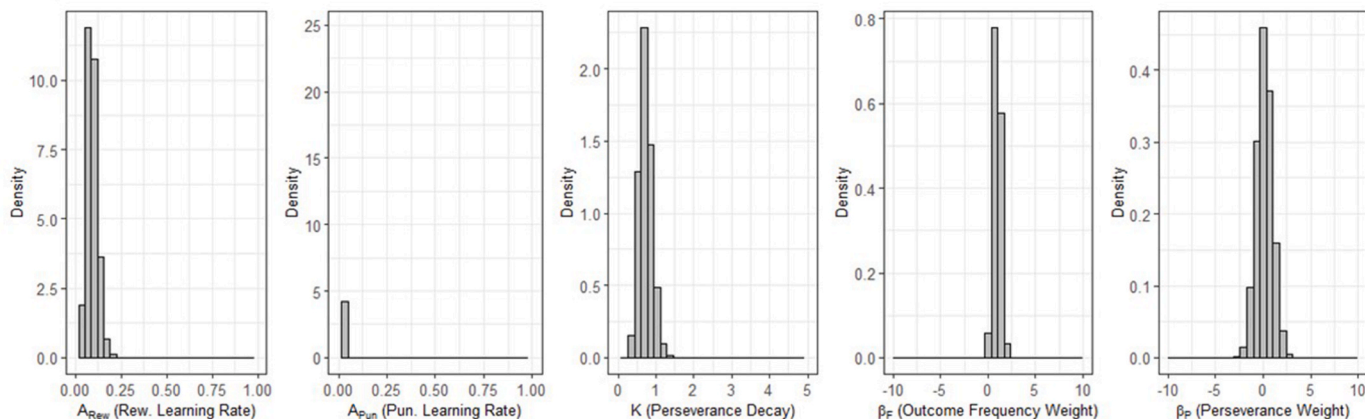
	Sexual Abusers (n = 63)	Controls (n = 60)	95% HDI
Reward learning ( $A_{rew}$ )	0.09 (SD = 0.03)	0.29 (SD = 0.04)	[HDI = - 0.299, - 0.099]
Punishment learning ( $A_{pun}$ )	0.01 (SD = 0.00)	0.05 (SD = 0.01)	[HDI = - 0.054, - 0.021]
forgetfulness ( $K$ )	0.73 (SD = 0.17)	0.22 (SD = 0.07)	[HDI = 0.168, 0.877]
Perseverance wins ( $B_p$ )	0.97 (SD = 0.37)	1.20 (SD = 0.27)	[HDI = - 1.130, 0.661]
Perseverance deck ( $B_p$ )	0.13 (SD = 0.84)	-2.45 (SD = 0.50)	[HDI = 0.659, 4.478]

## 4. Discussion

Contrary to what was expected, the final net score on the IGT was in favor of the ISOCs group compared to CTs, without significant difference. Indeed, the control group collapsed its scores at the end of the test. To date, no differences have been found when comparing the performance on IGT between sexual offenders and non-sexual offenders (Rodriguez et al., 2017), and a recent meta-analysis showed no significant differences comparing offender group and control (Jones et al., 2019). But even if we did not observe a significant difference on the final IGT net score between the two groups, we were able to show significant differences in the ORL parameters. Indeed, these findings highlight in ISOCs some impairments about feedback contingencies (reward and punishment) and difficulties in implementing long-term strategies with strong preference toward perseverance. This could be associated with a learning disruption highlighted by these results (perseveration in wrong choices and failure to integrate errors) without being able to account for the causality of the relationship between IGT performance and child sexual offense in this heterogeneous population of ISOC. Many previous studies have displayed lower score for executive function in ISOCs populations compared to adult sexual abusers (Joyal et al., 2014), non-sexual abusers or control populations (Rodriguez et al., 2017), with executive dysfunctions related to offense status rather than pedophilic preference (Massau et al., 2017). Some results display poorer working memory performance in CSO, more specifically in case of incest (Becerra-et al., 2014).

Previous studies using the ORL model on chronic cannabis users (Haines et al., 2018) or adolescents with excess weight (Moreno-Padilla et al., 2022) found an increase sensitivity to rewards and showed less perseverance (irrespective of the value of each deck) compared to healthy controls. These models, close to addictology, refer to an invasion of the judgment by the estimated reward, impacting the motivation in the choice, made on a compulsive modality. Child sexual abuse is expressed in very different ways (incest, rape, « Romeo and Juliet » offenders, child sexual abuse material offender ...) with a great heterogeneity in the offending process (Richetin and Richardson, 2008) and the neurocognitive profile of ISOCs (Suchy et al., 2009; Elliott et al., 2013). Impulsivity, compulsivity, or pedosexual addiction, are not always found in the offending process. Nor is the diagnosis of pedophilic disorder, which may be proposed in the case of persistent fantasies

### A) Sexual offenders



### B) Control group

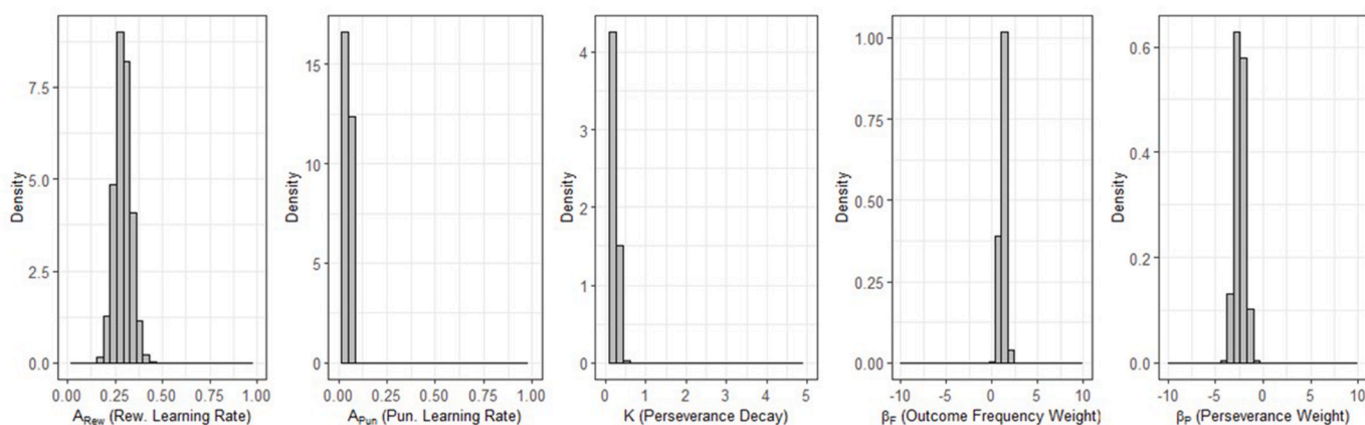


Fig. 2. Posterior distributions for each group (sexual offenders, control group) of the five components estimated from the IGT using the ORL model:  $A_{rew}$  = Reward learning rate,  $A_{pun}$  = Punishment learning rate,  $K$  = Perseverance decay/Forgetfulness,  $B_f$  = Outcome frequency weight,  $B_p$  = Perseverance weight.

outside of any aggression (American Psychiatric Association, 2013).

However, in a violent process, like for any cognitive processes of carrying out an act, “decisions to act emerge from the combination of preferences, drives and choices” (Koechlin et al., 2003). Concerning CSO, structural and functional alterations in the four main structures involved in this cognitive cascade have been identified (Wiebking and Northoff, 2013; Fonteille et al., 2012). First, some disturbance was shown in the orbitofrontal cortex (OFC) which is mainly involved in drive regarding to internal and external information and coding reward value with or without assignment of the sexual dimension (Richetin and Richardson, 2008; Balleine et al., 2011; Burns and Swerdlow, 2003). Secondly, disturbance was found in the functioning of the amygdala which is involved mainly in emotional responses and memories, control of reproductive behaviors, reward, and aversive conditioning (Sartorius et al., 2008). Thirdly, alteration was displayed in the Anterior Cingulate Cortex (ACC) (Poepl et al., 2015) which is sub-divided into two parts: affective (empathy, cooperation, emotional learning) and cognitive (cognitive control, cognitive flexibility). Finally, numbers of studies revealed dysfunctions in the PFC of CSO, which subserves complex executive functions and organizes behavior (Walter et al., 2007; Schiffer et al., 2008, 2017). These results are in agreement with previous studies showing impairment and riskier decisions in the CSO population.

Even if our sample is representative of the population from which it was drawn, these results concern an ISOC population with or without a diagnosis of pedophilia. Our study population is therefore heterogeneous in sexual preference and possible diagnoses of paraphilic disorder. Nevertheless, we observe in this ISOC population an alteration of

decision-making strategy with a significant association with depressive disorders and suicidal behaviors, in particular violent suicidal attempts. Neuropsychological alterations have already been revealed with IGT in patient populations with mood disorders (Alacreu et al., 2020) or a history of violent suicide attempts (Jollant et al., 2005). On the other hand, neuropsychological (De Bellis et al., 2009) and neurofunctional (Heim, 2000) alterations have been demonstrated in populations of victims of sexual violence, with specificities according to the type of trauma (Gould et al., 2012). These alterations favor the transition from victim to aggressor (« from Victim to victimizer ») (Rasmussen, 2012). In addition, the risk of having been abused as a child is higher in the CSO populations than in the general population (Plummer and Cossins, 2018). The neuropsychological alterations observed may be the cause or the consequence of the sexual violence experienced or suffered. Or they may take part in the repetition of violence. Thus, the diachronic link between the consequences of adverse events in childhood and the CSO perpetration in adulthood deserves more research in the perspective of a continuum between the violence suffered and acted out. Therefore, research should focus on neurobiological and neurofunctional prefrontal dysfunctions that cause an aberrant cortico-subcortical activation patterns likely shared by former victims (Plummer and Cossins, 2018), patients suffering from pedophilia (Tost et al., 2004), or minor attracted persons (Cohen et al., 2018) who become ISOCs. In light of these findings and the results of our research, ISOCs may share a transdiagnostic cognitive vulnerability underpinned by the frontal-cingulate-parietal-insular network (multi demand network) (McTeague et al., 2016).

In practice, this sequence of neurocognitive stages (preference, motivation, choice) deserves particular attention in ISOC population to identify deficits (regulation, cognitive control ...) or alterations (filtering defect, perseverance ...) allowing to target and adjust the treatment to the observed disorders and the subject's real capabilities. Finally, in criminological terms, the learning deficit and insensitivity to reward and punishment could question the effectiveness of some current punishment-based strategies for reducing recidivism.

This study has many limitations: although both groups performed the experimental task under the same circumstances, there was no financial incentive during the IGT since it involved virtual money. This may impact motivation to perform the task optimally and reward learning. These results are not specific, as IGT learning is a more general measure of decision-making processes that can only be used to account for reward learning and reward loss learning, and not for child sexual abuse. Furthermore, this type of reward learning cannot be generalized to other domains of learning (e.g., fear learning, social learning, etc.). In addition, the results could be impacted by cognitive alterations (attention, impulsivity, concentration, working memory, executive function) which have not been measured and controlled. The same applies to gender identity, race, and ethnicity, which have not been recorded as this is forbidden in France for ethical reasons. The ISOC group is highly heterogeneous (with or without contact, on and off-line offenders, intra-familial and extra-familial offenders ...) and this sample is not representative of all men who commit sexual violence against children. Only convicted offenders are involved in the study. Similarly, clinical variables, particularly in the ISOC group, should be controlled to improve the relevance of this results: age, personality traits, incarceration status, criminal history, sexual preference, history of trauma and sexual abuse, paraphilic disorders. In summary, our findings confirm neuropsychological impairments in a population of ISOCs with a tendency to make unfavorable choices concerning feedback contingencies (reward and punishment) and difficulties in implementing long-term strategies with strong preference toward perseverance. These findings, which need to be replicated and consolidated, could have potential implications for research, treatment and recidivism prevention strategies based on reward and punishment learning.

#### CRedit authorship contribution statement

**Mathieu Lacambre:** Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources, Validation, Writing – original draft, Writing – review & editing. **Adrián Alacreu-Crespo:** Formal analysis, Software, Validation, Visualization, Writing – original draft. **Hélène Huguet:** Data curation, Formal analysis, Funding acquisition, Methodology, Resources, Software, Validation, Visualization, Writing – review & editing. **Thibault Mura:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – review & editing. **Philippe Courtet:** Funding acquisition, Methodology, Project administration, Resources, Supervision, Validation, Writing – review & editing.

#### Declaration of competing interest

All authors report no financial or personal relationships with other people or organizations that could inappropriately influence their research work presented in this article.

For reasons of clarity and completeness: Philippe Courtet reports no shares; stands on the advisory board at Janssen; and has received honoraria or research or educational conference grants from Otsuka, Lundbeck, Exeltis, Pfizer and Janssen. Mathieu Lacambre has received speakers and CME activity honoraria from Eisai. The other authors report no financial relationships with commercial interest.

#### Acknowledgments

Dr Lacambre was supported for this research by University Hospital of Montpellier grant ID-RCB 2011-A00402-39. We would like to thank Cindy Prudhomme and Cécile Jubine for the data collection, Wayne Bodkin and Jean-Baptiste Lacambre for their careful review, Walter Albardier, Barbara Thomazeau and the INSERM U1061 team for their support.

#### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jpsychires.2024.12.035>.

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