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Research Article

# Reward-Punishment Processing Deficits in Schizotypy with Callous Unemotional Traits

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## Abstract

**Background:** Schizophrenia is associated with reward-punishment processing deficits. However, these deficits in schizotypy who are at risk for schizophrenia warrants investigation. The present study aimed to investigate reward-punishment processing ability in schizotypy with psychopathic traits, specifically callous-unemotional traits in adolescents and young adults.

**Method:** Sixty-six participants (mean age: 20.4 years) participated in this study and 60 of them finished all the assessments. The participants were divided into two groups based on their schizotypal characteristics: 28 schizotypy and 32 healthy controls. Schizotypal Personality Questionnaire-Brief and Antisocial Processing Screening Device were used to measure participants' schizotypal characteristics and psychopathic traits respectively. Participants' reward-punishment processing was assessed by Monetary Incentive Delay Task (MID).

**Results:** Results showed that the levels of schizotypy ($p = .06$) and the interaction effect (levels of schizotypy × callous-unemotional traits) marginally significantly and significantly predicted the MID accuracy ($p = .03$). Specifically, the schizotypy group performed less accurately in the MID task when compared to the controls. Callous-unemotional traits were negatively associated with the MID accuracy in schizotypy ($r = -.50$, $p < .05$) but not in the controls ($p > .05$).

**Conclusion:** Findings suggest that reward-punishment processing is impaired in schizotypy who are at-risk for developing schizophrenia. Particularly, these deficits are exacerbated in those schizotypy individuals with an increased level of callous-unemotional traits. Intervention for schizophrenia spectrum disorders is suggested to incorporate the component to enhance callous-unemotional traits, thereby ameliorating reward-punishment processing deficits in these individuals.

***Keywords:*** *Reward-Punishment Processing; Schizotypy; Callous-Unemotional Traits; Psychopathy*

## Introduction

According to National Institute of Mental Health [1] the prevalence of schizophrenia-spectrum disorders in the U.S. ranged from 0.25% to 0.64% [2-4]. In terms of sub-clinical schizotypal characteristics, an approximately 10% individuals had schizotypal personality traits (schizotypy) who are at risk for the development of schizophrenia-spectrum disorders in the community [5,6]. Reward and punishment processing was found to be impaired in schizophrenia [7-9] and this deficit was closely related to callous-unemotional traits (CU). Notably, the CU traits were associated with schizotypal individuals [10,11]. For instance, females with schizotypal personality dis-

order (SPD) were found to be positively correlated with these traits [12]. The aforementioned studies investigating schizotypal traits and CU traits have indicated the importance of further study on the underlying mechanism of such relationship.

Schizotypy is a multidimensional personality construct that is comprised of attenuated schizophrenia-spectrum disorder symptoms. It is conceptualized as an endophenotype for the development of schizophrenia [13,14]. Specifically, both of them share similar neurological, psychological and behavioral characteristics including interpersonal impairment, cognitive-perceptual deficits and disorganized speech and behaviours [13,15]. Little research has focused on the CU traits in schizotypal population. Since CU traits in adolescents are precursors to later criminal offending in adulthood, Huang., *et al*. [16] examined the impact of CU traits on the reward-punishment processing. Findings extended the evidence of greater association of responsivity to reward and punishment with CU traits. It was found that individuals with SPD exhibited lower levels of emotional clarity and higher negative affect [17] which shared considerable concepts of CU traits [18]. Notably, Polek., *et al*. [18] took psychopathic traits and schizotypal traits into account, as a bifactorial model, to examine its indexing ability on social dysfunction. Findings suggested that the model showed high reliability and validity on social impairment which provided an insight of the underlying mechanism of how the factors influencing the impairment behaviorally. The performance of schizophrenia patients on a goal-directed reward probabilistic learning task revealed significant less correct responses with moderate uncertainty [19]. The results of reward learning deficits in patients with schizophrenia implicating the impaired decision-making performance may influence goal-direct behaviour. Given that the reward-punishment processing, the social impairment was found to be impaired in individuals with schizophrenia and psychopathic traits [7-9] whereas schizophrenia and schizotypy share similar deficits and features [20,21] as well, the present study was sought to investigate the reward-punishment processing deficits in schizotypy.

Previous studies [22,23] have well documented that a number of personality traits (negative emotionality, schizotypy, narcissistic trait, callous-unemotional trait, antisocial trait and impulsivity trait) are associated with social impairment, specifically the reward-punishment processing deficits [24,25]. For instance, prior studies found that risky decision-making, which is an index of reward and punishment processing ability, was impaired in schizophrenia and schizotypy [26,27]. Furthermore, Cai., *et al*. [28] found that individuals with higher levels of negative schizotypy had altered anticipatory reward processing. Along the same line, symptoms of schizophrenia, such as anhedonia and avolition, were originated from deficits in reward-punishment processing as well [29,30]. Notably, those with high levels of social anhedonia which was related to schizotypy obtained less reward from social stimuli [31]. Although previous findings have suggested that high levels of negative schizotypy might have impairment in processing social incentives and monetary rewards, the pattern of processing rewards and punishment in schizotypy with different psychopathic traits warrants further investigation.

If the reward-punishment processing deficit is found in both schizophrenia and schizotypy, what would be the underlying factor of this relationship? Martin., *et al*. [24] demonstrated an association of anticipatory and consummatory with schizotypal individuals with emotional deficits with mixed results. Notably, schizotypal individuals' with social anhedonia showed decreased attention to positive emotion, as well as decrease anticipatory and consummatory pleasure. Comparably, Marini and Stickle [11] revealed that the decreased reward responsivity could be predicted by higher levels of CU traits. It was found that the CU traits were associated with the deficits in responding to rewards and punishment [11,32]. Another study by Centifanti and Modecki [33] revealed that individuals with high callous-unemotional traits had problems in managing their behavior when confronting with rewards. Furthermore, previous findings showed that CU traits were significantly related to risky decision-making [34] or punishment insensitivity [35] which were indexes of reward-punishment processing abilities. These deficits in those with CU traits might be explained by the amygdala dysfunction, which was suggested by the Integrated Emotion System (IES) [36]. More importantly, these previous findings led to the speculation that CU might play an important role in the relationship between schizotypy and reward-punishment processing. To be specific, it is speculated that schizotypy especially those with CU traits would have more reward-punishment processing problems when compared with those with fewer CU traits. Since the dysfunction in reward-punishment processing in schizotypy might result in real-life general functioning problems as well as familial and financial burden, [37] the present study examined the reward-punishment processing abilities in schizotypy with high and low CU traits.

## Aim of the Study

The present study aimed to examine 1) whether schizotypy had reward-punishment processing deficits, and 2) the relationship between reward-punishment processing ability, CU traits and schizotypy. It was hypothesized that 1) schizotypy performed worse on the reward-punishment processing when compared to healthy controls and 2) schizotypy with higher CU traits performed worse than those with lower CU traits.

## Methods

### Participants

Participants were recruited from secondary schools in the community and they had to meet the inclusion criteria for the participation in this study: (a) not diagnosed with an Axis I psychotic diagnosis according to the Diagnostic and Statistical Manual of Mental Disorders, 5th edition, [38] (b) without a history or current presence of neurological diseases, and (c) without the presence of medical diseases. A total of 66 participants (41 males and 25 females; mean age = 20.4 years; SD = 4.7) who fulfilled the inclusion criteria were selected to participate in this study and 60 of them successfully completed all the assessments. Adopting the criteria by previous study, [39] these selected participants were categorized as schizotypy group if they: (a) scored 9 or above in the Chinese version of Prodromal Questionnaire (CPQ-16), (b) scored above 8.18 in the Chinese version of Community Assessment of Psychic Experiences (CAPE-C15), and (c) scored of 17 or above in the Chinese version of Schizotypal Personality Questionnaire-Brief (SPQ-B). The remaining participants who did not meet the above criteria were identified as healthy control group.

### Procedure

The current study was approved by the Human Subjects Ethics Sub-committee (HSESC) of Hong Kong Polytechnic University (approval number: HSEARS20180906006) in accordance with the ethical standards. After obtaining the informed consent from the participants and their parents (for the participants under the age of 18), a set of self-report questionnaire consisted of the Chinese version of Prodromal Questionnaire (CPQ-16), Chinese version of 15-item Community Assessment of Psychic Experiences (CAPE-C15) and Chinese version of Schizotypal Personality Questionnaire-Brief (SPQ-B) as well as demographics information was administered to the participants. Participants were then categorized as schizotypy if they met the aforementioned criteria while the remaining ones were categorized as healthy controls. The Monetary Incentive Delay Task (MID) and Antisocial Process Screening Device (APSD) were also administered to the participants.

### Instruments

#### Schizotypy

Adapting the criteria by Moritz., *et al.* [39] three self-report screening scales were used to differentiate those with schizotypy from healthy controls in the present study: the Chinese version of Prodromal Questionnaire (CPQ-16), the Chinese version of 15-item Community Assessment of Psychic Experiences (CAPE-C15) and the Chinese version of Schizotypal Personality Questionnaire-Brief (SPQ-B).

The CPQ-16 is a self-report screening scale identifying the at-risk schizotypal mental state [40]. The participants were asked to report the presence or absence of each symptom with a total of 16 true/false items targeting people's subjective experiences over the past month. It consists of 9 items tapping on hallucinations and perceptual abnormalities, 5 items tapping on paranoia, delusional ideas and unusual though, 2 items concerning negative symptoms. For example, subjects were asked to rate a statement of "I feel uninterested in the things I used to enjoy" in a dichotomous ratings (true/false). Distress was then measure on a 4-point scale for item marked as true ranging from 0 (none) to 3 (severe) if the primary response is "true". The CPQ-16 score was obtained by adding up the distress score. The present study adopted the cut-off score of 9 to differentiate the presence of prodromal syndromes, namely scored 9 or higher referred as presence of prodromal syndrome whereas scored less than 9 referred as absence of prodromal syndrome. The adopted cut-off score of 9

had a sensitivity of 85% and a specificity of 87% in distinguishing at-risk schizotypy and non-at-risk schizotypy [40]. The present study obtained good internal reliabilities for the overall scale (α = .86).

The CAPE-C15 is a self-report scale assessing lifetime psychotic-like feelings, thoughts or mental experiences [41]. The participants were asked to rate on a four-point Likert scale from 1 (never/a bit distressed) to 4 (nearly always/very distressed) to indicate the frequency and distress separately. The present study obtained good internal reliabilities for the overall scale (α = .74) and its subscales: positive psychotic experiences (α = .42), negative psychotic experiences (α = .60) and depressive experiences (α = .55). The present study adopted the cut-off score of 8.18 which had a sensitivity of 79% and a specificity of 78% [35]. Acceptable internal reliability of CAPE-C15 was also reported in previous study [35]: overall (α = .82), positive scale (α = .74), negative scale (α = .69) and depressive scale (α = .75).

The early psychotic symptoms of schizotypal characteristics were measured by the 22-item of Chinese version of SPQ-B, which is a short version of the 74-item SPQ [42]. The participants were asked to rate 1 (yes) or 0 (no) for each item based on their experience in the past six months. The present study showed an acceptable Cronbach's alpha of SPQ-B assessing overall schizotypy traits ($\alpha$ = .84).

### The antisocial process screening device (APSD)

Psychopathic-like traits of the participants were assessed by the self-report Antisocial Process Screening Device (APSD). It consists of 20 items tapping three sub-scales: callous-unemotional traits, narcissism, and impulsivity [43]. Participants were asked to rate on a 3-point scale either 0 (not at all true), 1 (sometime true) or 2 (definitely true). Its subscales tapping narcissism ($\alpha$ = .63), impulsivity ($\alpha$ = .66) and callous-unemotional traits ($\alpha$ = .53) received good reliabilities ($\alpha$ = .69) in the current study.

### Monetary incentives delay task

The Chinese version of the Monetary Incentive Delay Task (MID) was adapted from Knutson and colleagues [44] to measure participants' reward and punishment processing ability. A Pavlovian conditioning procedure was used with each trial divided into two phases: anticipation and reception. The anticipation phase began with an affectively neutral visual cue (geometric form) displayed for 2000 milliseconds followed by a 2000 to 2500 milliseconds fixation cross. Each geometric cue was associated with a particular outcome (circle as win, square as lose and triangle as no win or lose). Immediately after the anticipation phase, a target appeared briefly and response was required to make (within a 180 to 280 millisecond time window). If the targets were hit within the time window during reward trials, participants would win $2.00/$0.50, otherwise they would gain $0.00. If the targets were hit on punishment trials result in losing $0.00, whereas a miss would result in losing $2.00/$0.50. Hit or missed the neutral trials result in neither gain nor loss (+/- $0.00). To maintain the subjects' attention, they were asked to response as soon as the target appears. Before the experimental condition, the participants were asked to gain as much as they can and complete the practice conditions to familiarise themselves. In the experimental condition, there were a total of 45 trials: 15 reward, punishment, and neutral trials each. Participants' percentage accuracy was recorded in the present study by calculating the number of trial they hit over the total number of trial.

### Statistical analyses

Correlational and hierarchical multiple regression analyses were conducted using SPSS version 22.0 [45] in the present study. The significance threshold for all analyses was set at $p < 0.05$ for all analyses.

## Results

The average age, SPQ-B and CPQ-16 mean scores of the control group were significantly different from that of the schizotypy group with large effect sizes of 0.62, 0.78 and 1.02 respectively (ps < 0.05). Table 1 reports the means and standard deviations of the demographics information and major variables in schizotypy and healthy participants.

| | Schizotypy (N = 28) | Control (N = 32) | t/ χ2 statistics | d |
|---|---|---|---|---|
| | Mean (SD) | Mean (SD) | | |
| Age | 18.5 (3.2) | 20.9 (4.4) | t(58) = 2.35* | .62 |
| Sex (% of males) | 68.8 | 53.6 | χ2(1) = 0.23 | .31 |
| Education Level (% of university or above) | 59.4 | 57.1 | χ2(4) = 0.87 | .16 |
| SPQ-B Mean Score | .4 (.2) | .3 (.2) | t(57) = -2.99** | .78 |
| CPQ-16 Mean Score | .3 (.2) | .1 (.1) | t(58) = -4.01*** | 1.02 |
| APSD Mean Score | .6 (.2) | .53 (.2) | t(58) = -1.59 | .41 |
| MID-Accuracy (%) | 52.8 (7.1) | 54.9 (5.0) | t(46) = 1.20 | .34 |

***Table 1:*** *Mean and standard deviations for the demographics information in schizotypy and healthy controls.*

*Note. SPQ-B: Schizotypal Personality Questionnaire-Brief; CPQ-16: The Chinese version of Prodromal Questionnaire; APSD: The Antisocial Process Screening Device; MID: Monetary Incentive Delay Task.*

** p <= .05; ** p <= .01; *** p <= .001.*

## Correlations between major variables

Table 2 demonstrates the correlations and the significance among the major variables. Significant positive correlations were found between 1) SPQ-B total score and impulsivity of APSD (r = .61, p <= .01) and 2) impulsivity of APSD and narcissism of APSD (r = .45, p <= .01). Other correlations between the SPQ-B, APSD subscales and MID accuracy were not significant (p > .05).

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1. SPQ-B score | - | | | | |
| 2. APSD - impulsivity | .61** | - | | | |
| 3. APSD - narcissism | .21 | .45** | - | | |
| 4. APSD - CU traits | .17 | .11 | -.09 | - | |
| 5. MID percentage accuracy | -.11 | .02 | .24 | -.27 | - |
| *Mean (SD)* | .35 (.20) | .66 (.39) | .47 (.30) | .65 (.29) | 54.08 (8.27) |

***Table 2:*** *Correlations between major variables (SPQ-B, APSD and MID accuracy).*

Note. *p < 0.05, **p < 0.01, ***p < 0.001.

*SPQ-B* : *Schizotypal Personality Questionnaire-Brief; APSD: Antisocial Process Screening Device; MID: Monetary Incentive Delay; SD: Standard Deviation.*

## Hierarchical multiple regression analyses

Hierarchical multiple regression analyses were performed to test the prediction of major variables (SPQ-B and APSD subscales including callous-unemotional traits) to the accuracy in MID. In the regression model, sex and all three APSD subscales were entered in the first step while schizotypy and the interaction effect (level of schizotypy × callous-unemotional traits) were entered in the second step. In the first step ($F(5, 38) = 1.27$, $p = .30$, Cohen's $f^2 = .17$), sex, level of schizotypy and all three APSD subscales were not significant in predicting MID accuracy ($p > .05$) (Table 3). There were no main effects of callous unemotional traits ($p = .11$) and level of schizotypy ($p = .73$) on the accuracy in MID. In the second step ($F(6, 37) = 2.02$, $p = .09$, Cohen's $f^2 = .33$), after controlling sex, group and all three APSD subscales, the accuracy of the MID performance was marginally significantly predicted by the level of schizotypy ($\beta = .73$, $t = 1.93$, $p = .06$) and the

interaction effect (level of schizotypy × callous-unemotional traits) ($\beta$ = -1.37, t = -2.25, p = .03) (Table 3). Specifically, as can be seen in figure 1, the schizotypy group (M = 52.77; SD = 7.13) performed less accurately in the MID task when compared to the controls (M = 54.88; SD = 5.04). A negative correlation was found between callous-unemotional traits and the accuracy in MID (r = -.50, p <= .05) in schizotypy group while this association was not significant in the control group (r = .04, p > .05).

| | Step 1 | | Step 2 | |
|---|---|---|---|---|
| | β | t | β | t |
| Sex | -.13 | -0.86 | -.04 | -.26 |
| APSD - Impulsivity | -.06 | -.30 | -.05 | -.26 |
| APSD - Narcissism | .24 | 1.27 | .27 | 1.50 |
| APSD - Callous Unemotional Traits | -.27 | -1.63 | .73 | 1.56 |
| Level of schizotypy | -.05 | -.35 | .73^ | 1.93 |
| Level of schizotypy × level of callous unemotional traits | | | -1.37* | -2.25 |
| Cohen's $f^2$ | 0.17 | | 0.33 | |
| $R^2$ | .14 | | .25 | |
| $R^2$ change | - | | .11 | |

***Table 3:*** *Hierarchical multiple regression analyses in predicting the accuracy of the monetary incentive delay (MID) task.*

Note. ^p < 0.06, *p < 0.05.

APSD: Antisocial Process Screening Device; β: Standardized Coefficients.

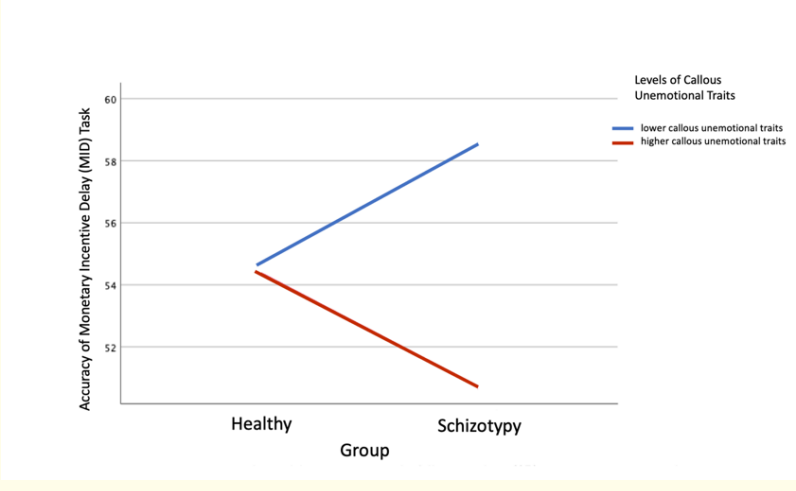


***Figure 1:*** *Interaction effect (Level of callous unemotional traits × level of schizotypy) on the accuracy of reward and punishment processing measured by monetary incentive delay (MID) task.*

*Note: The results showed an interaction effect (level of schizotypy callous-unemotional traits) (β = -1.37, t = -2.25, p = .03) in predicting reward and punishment processing ability. The schizotypy group (M = 52.8; SD = 7.1) performed less accurately in the MID task when compared to the controls (M = 54.8; SD = 5.0). A negative correlation was found between callous-unemotional traits and the accuracy in MID (r = -.50, p <= .05) in schizotypy group while this association was not significant in the control group (r = .04, p > .05).*

## Discussion

The present study examined the reward punishment processing ability in adolescents and young adults with schizotypy and CU traits who lived in the community. The major findings of the present study was that schizotypy and the interaction effect between schizotypy and callous-unemotional traits significantly predicted the reward and punishment processing ability in these individuals. The findings were consistent with a priori hypothesis which supported previous findings [46,47]. As expected, these findings suggested that reward-punishment processing ability was impaired in schizotypy, and it was particularly exacerbated by an increased level of CU traits in individuals with schizotypy.

### Schizotypal and CU effect on reward-punishment processing

Reward-punishment processing has been found to be impaired in individuals with schizophrenia-spectrum disorder [7,20,26] as well as in the individuals with CU traits [33]. However, very few studies were conducted to investigate the reward-punishment processing in schizotypy with different levels of CU traits [28]. To go beyond previous findings examining on schizotypy and CU traits separately [28] the interaction effect (schizotypy x CU traits) found in the current study indicated that CU traits moderated the effect of schizotypy on reward-punishment processing ability with a moderate effect size (Cohen's $f^2 = 0.33$). Specifically, the schizotypy with higher CU traits had worse reward and punishment processing ability when compared with those with lower CU traits. Although CU traits were not associated with reward-punishment processing impairment in the present study and previous studies [33,36] the current findings suggested that reward-punishment processing was more impaired in schizotypal individuals with high level of CU traits when compared to their counterparts (schizotypy with low level of CU traits). These findings suggested that CU traits played a significant and detrimental role in the reward-punishment processing in schizotypy individuals [31]. The present findings help explain the conflicting and non-significant results regarding the effect of CU traits on reward-punishment processing in previous studies [11,33]. More importantly, they were consistent with the a priori hypothesis that schizotypy with high CU traits performed worse than their counterparts in the present study.

The interaction effect observed in the present study can be explained by cognitive-affective and neural perspectives [33]. Specifically, schizotypy is related to social withdrawal, reduced cognitive capacity and affective dysregulation whilst CU traits are related to disregard for others, lack of empathy and generally deficient affect. The worsening performance of reward-punishment in schizotypy with high CU traits could be regarded as lack of emotion and cognitive capacity which in turn heighten the rationality and accuracy in responding to rewards and punishment [33]. Moreover, a significant body of work demonstrated that individuals with high CU traits were more likely to develop antisocial behavior and aggression which was closely related to reward and punishment processing.

Although the current findings only showed marginal significant relationship between schizotypy and reward-punishment processing ability which is consistent with prior findings [28,48] it is noteworthy to consider the differential correlations found in schizotypy and healthy controls in the present study. Specifically, a significant negative correlation between CU traits and reward and punishment processing performance was found in schizotypy but not in healthy controls. Likewise, Cai., *et al*. [28] found that low level of schizotypy exhibited better reward-punishment processing. Also, the findings by Cai., *et al*. [28] and Li., *et al*. [49] both observed that higher negative schizotypy demonstrated a stronger association with the reward and punishment processing deficits. Specifically, amygdala dysfunction, which was found in schizophrenia-spectrum disorder and the individuals with CU traits [50] was suggested to hinder the establishment of affect representations and pose the difficulty in processing social information and accommodating the meaning of the social cues [51,52]. In addition, the neuroimaging study by Yan., *et al*. [48] revealed that high level of negative schizotypy showed diminished activation in the amygdala during reward-punishment processing. Along the same line, Kirschner., *et al*. [53] found that these reward-punishment processing deficits were prominent across the psychosis continuum and non-clinical individuals with schizotypy. In terms of the neurobiological findings, previous studies found a significant association between schizotypy, reward-punishment deficits and impaired adaptive coding with the amygdala [50-52]. These previous findings suggested that schizotypy which was related to amygdala dysfunction had more

problems in processing reward and punishment when compared to healthy controls. Taken all these behavioral and neurobiological findings together, the present findings regarding schizotypy, CU traits and reward-punishment processing are consistent with prior findings.

## Limitations of the Study

The current study encountered a number of limitations which should be addressed in future studies. First, although the present sample was recruited and selected from a large sample of primary and secondary schools, the sample size was relatively small. Although the effect size was moderate in the present study, future studies are suggested to replicate the study with a larger sample size which would further validate the present findings. Second, the reliabilities of the CAPE-C15 and APSD were only moderate which might be because of the sample size. Future studies should address this limitation by recruiting a larger sample size.

## Conclusion

The present study examined the relationship of reward-punishment processing, schizotypy and CU traits in adolescents and young adults who lived in the community. The key findings revealed the interaction effect (schizotypy × CU traits) on reward-punishment processing, suggesting that in addition to the level of schizotypy, the level of CU traits also play a paramount role in exacerbating the reward-punishment deficits in these individuals. These findings suggested CU traits to be the potential underlying mechanism of the reward-punishment processing deficits in schizotypy. In light of the prior studies demonstrating the reward-punishment deficits in schizophrenia-spectrum disorder, the findings of the present study could give insight by revealing the deficits in the sub-clinical individuals, schizotypy. Future intervention for reward-punishment processing deficits in schizotypy are suggested to incorporate the component to enhance CU traits in adolescents and young adults.

## Conflicts of Interest

The authors declare that they have no conflict of interest.

## Ethics Approval

Ethics approval was obtained from the Human Ethics Committee at the Hong Kong Polytechnic University.

## Consent to Participate

Written informed consent was obtained from all participants.

## Consent for Publication

Written informed consent was obtained from all participants.

## Availability of Data and Material

Available upon request.

## Code Availability

Not applicable.

## Funding Support

Not applicable.

## Authors' Contributions

BYHL conceptualized and monitored all processes of this study. KSL collected and analyzed the data, and wrote the first draft. BYHL revised and finalized the manuscript. All authors have read and approved the content of this manuscript.

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