

# Improving Anticipatory and Consummatory Anhedonia over the Covid-19 Pandemic

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## Abstract

**Background:** COVID-19 lockdown restrictions have caused a significant constraint on our ability to engage in many enjoyable and rewarding activities. However, less evidence is available how pleasure capacity may be affected. The current study investigated changes in anhedonia during different phases of the Chinese lockdown including the lockdown and post-lockdown as compared to pre-lockdown.

**Methods:** Data were collected at 7 time points from 345 Chinese university students monitored across twenty-six months from October 2018 to December 2020 measuring anticipatory and consummatory anhedonia, depressive symptom, child maltreatment, self-harm behavior and COVID-19 relative stressors. The multivariate linear mixed model was used to examine the overall change in anhedonia over time.

**Results:** Compared with pre-lockdown, anticipatory and consummatory anhedonia significantly decreased following the lockdown, but failed to find significant changes between during and post-lockdown. The same improvement pattern was found in depressive symptoms. Individual with emotional neglect showed a less decrease in anticipatory anhedonia whereas those with emotional abuse showed a less decrease in consummatory anhedonia. Higher COVID-19 relative stressors predicted less anticipatory and consummatory anhedonia.

**Conclusions:** Chinese undergraduates appear to experience better pleasure capacity during the pandemic. Such positive changes have important implications on how to cultivate the ability to engage enjoyable activities in the future crises.

**Keywords:** Improvement • Anhedonia • Depression • Stress • COVID-19 • Lockdown

## Introduction

The COVID-19 has already lasted for three years since the first case was reported, heavily constraining on the ability to engage in enjoyable activities

that people normally experience positive emotions. The loss of pleasure or interest in enjoyable activities is clinically known as anhedonia, which is a trans diagnostic symptom in main psychiatric and neurological disorders [1]. Individuals with anhedonia have an increased likelihood of more severe symptoms, worse treatment prognosis and effectiveness [2]. In the general population, the ability to experience pleasure seems essential for subjective well-being, pointing towards anhedonia has repeatedly been associated with a higher risk of developing a mental disorder and a decrease in overall quality of life [3,4]. However, less evidence is available for the COVID-19 impact on anhedonia. Cross-sectional studies found elevated state anhedonia during the pandemic among general population [5]. Post-COVID-19 patients [6,7]. But these conclusions were drawn without comparable pre-pandemic information. One longitudinal study reported higher anhedonia and lower anticipatory reward responsiveness among college students during the initial months of the pandemic compared with pre-pandemic. But their sample was very small (n=87). Further investigation covering the entire period of the lockdown would be particularly beneficial to characterize the time course of the hedonic capacity changes associated with the pandemic.

Anhedonia traditionally is conceptualized as a unitary construct of diminished online pleasure experience [8]. But research on reward processing suggest anhedonia is a multidimensional construct that comprises at least two components with distinct neural networks, namely anticipatory and consummatory pleasure [9,10]. Anticipatory pleasure is the ability to experience a motivated and goal-directed behavior for a future pleasant event whereas consummatory pleasure is the ability to experience in-the-moment pleasure when an individual is directly engaging in an enjoyable activity. Neurobiological studies further posited that anticipatory anhedonia was more closely associated with dopamine pathway and striatal circuitry, while consummatory anhedonia was more strongly linked to the opioid system and the ventromedial prefrontal cortex. For example, the orbitofrontal and cingulate cortices as well as the insular cortices contribute to consummatory pleasure [11]. Subcortical areas such as the ventral/dorsal striatum and the amygdala have been implicated in the processing of anticipatory pleasure. In particular, the orbitofrontal cortex takes up an important role in linking anticipatory reward to hedonic experiences. Evidence found that the lockdown measures had triggered brain inflammation among health individuals [12]. That could contribute to sustained deficits in reward processing necessitating further investigations into COVID-19 and anhedonia, especially how anticipatory and consummatory pleasure may be affected by COVID related stress.

The pandemic is considered as a new type of traumatic stressor, being an unexpected event, causing a severe disruption of daily routine life [13]. Several conceptual models for anhedonia and stress have been proposed. Laos proposes that anhedonia is an inherited trait and usually becomes apparent in adolescence. Early adverse events could create displeasure experience, low sensation-seeking, and negative emotions, which increase vulnerability for developing depression. Pizzagalli offers a biopsychological explanation for this association in which early exposure to childhood adversities blunts brain dopaminergic pathways, subsequently leading to anhedonia responses [14]. Literature strongly supported that prolonged exposure to chronic unavoidable stressors was most damaging for reward circuits, resulting in a downregulation of mesolimbic dopaminergic pathways and reduced responsiveness to rewarding stimuli [15,16]. During lockdown, higher stress was related to increase state anhedonia among general population [17]. Daniels and to lower levels of motivation and pleasure capacity. In China, unlike most Western countries, local strict lockdowns balance the prevention and control of this disease with socioeconomic stability with "Dynamic COVID-zero" strategy [18]. However, the chronicity of the strategy along prolonged social disruption may have

brought durable and uncontrollable stress. As noted above, chronic stress is the detrimental for developing motivational deficits, anhedonia and clinical depression. This could be more profound impact on brain reward system and anhedonia for Chinese people.

The current study aimed to investigate short- and long-term changes in anhedonia during the Chinese lockdown period in a sample of Chinese university student monitored across 3 year with seven waves from September to 2018 December 2020. In particular, the study sought to identify whether anhedonia changed during the different stages of lockdown, either increasing during the onset of lockdown, or decreasing as the restrictions were lifted, or continuously decreasing as individuals returned to usual circumstances. The secondary aim was to identify the impact of different psychosocial factors on anhedonia changes including exploring:

- which socio-demographic characteristics or vulnerable groups were risk factors for anhedonia,
- whether childhood traumatic experience and COVID-related stress may explain the higher anhedonia levels during the COVID-19 crisis.

## Methodology

### Participants

The current study was based on data from the previous project examining the relationship between anhedonia and suicidal ideation in university students [19, 20]. At the baseline assessment (Time 1), all first-year students at School of Education in the Hunan Agricultural University were invited to participate in the study. Of the 548 invited students, 345 students participated in the present study through online survey platform (www.wjx.com) in October 2018. The second survey (Time 2, N=183, 60%) was completed between 6 December-30 December 2018. The third survey (Time3, N=321, 93.04%) was conducted between 3 September-30 September 2019. At the beginning of the Covid-19 outbreak, invitation letters for the follow-up survey were sent and 282 students (Time 4, 81.74%) responded to the fourth survey at the fourth week of lockdown between 13 to 28 February 2020. The fifth survey (Time 5, N=260, 75.36%) took place 2 months into the lockdown between 6 April and 9 May 2020, when restrictions were eased. The sixth survey (Time 6, N=304, 88.12%) was conducted 7 months after lockdown between 17 September to 21 October 2020, when university reopened 3-7 weeks. At that time, university students had not attended university for eight and a half months since the winter holiday. The seventh survey (Time 7, N=268, 77.68%) was completed from 1 December to 30 December 2020, 10 months after lockdown. The following exclusion criteria were applied:

- Potential eligible students (n=184) at the baseline were not willing to participate in the study;
- 8 students were inclined to respond to the items in a similar pattern more than 3 waves (e.g., chose the same answer within the whole questionnaire);
- Participants answered twice and their second answers were excluded;
- 6 participants' completion time were shorter than 416 s (2.5<sup>th</sup> percentile) or longer than 3386 s (97.5<sup>th</sup> percentile) more than 3 waves.

Overall, 345 students effectively completed at least one observation pre-lockdown and at least two observations post-lockdown, comprised of 233 (67.5%) females, with a mean age of 18.00 (SD=0.71), see Figure 1. Ethical approval was obtained from the Institutional Review Board of the Hunan Agricultural University (2018-118; 2020-026). Informed consent was taken before the survey started. Participants progressed to the online questionnaire when agreeing to the consent option ("I read, understand and agree"). Participants were asked to provide abbreviations of their name to match the follow-up data.

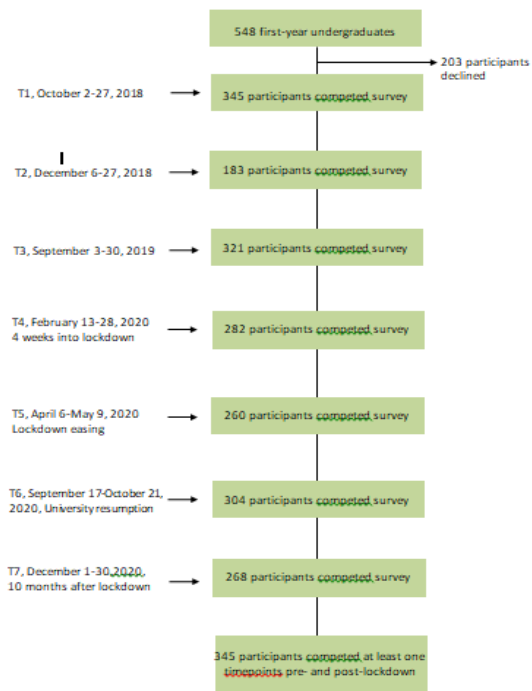


Figure 1. Flow chart of participants included in the study.

### Measure

Sociodemographic and pre-existing mental health variables. The following variables were provided:

- gender,
- age,
- region (city, country),
- monthly household income (high, average, low),
- a diagnosed mental health problem (yes, no),
- family history of mental health disorders (yes, no),
- current alcohol consumption or smoking (yes, no),
- COVID-19 diagnosis (yes, no),
- suicide attempt was assessed with the question: "Have you ever committed a suicide attempt before?" (yes, no),
- suicidal ideation was assessed with the first five items in the Beck Scale for Suicide Ideation (BSS), a cut-off score of 1 on items 4 and 5 is usually used to categorise suicidal ideation (yes, no) [21].

### Child maltreatment

The Childhood Trauma Questionnaire-Short Form (CTQ-SF) was used to assess child maltreatment experience at home. It is a 28-item retrospective self-report questionnaire with a 5-point Likert scale ranging from 1 (not at all) to 5 (very often), which is divided into five subscales: emotional abuse, emotional neglect, sexual abuse, physical abuse, and physical neglect. The cut-off of each subscale is emotional abuse  $\geq 13$ , emotional neglect  $\geq 15$ , sexual abuse  $\geq 8$ , physical abuse  $\geq 10$ , and physical neglect  $\geq 10$ , respectively. Each subscale ranges from 5 to 25 and the total score ranges from 25 to 125.

### COVID 2019 stressful events

This self-rated scale was developed by the author (X.Y.) and was used to evaluate stress experienced due to lockdown restrictions. Further detail is available in Supplemental Text 1. Each participant was required to assess the influence of these events from 1 (not at all) to 5 (very severe), with a higher total score indicating a greater number of stressful experiences.

### Depressive symptoms

The Chinese version of the Beck Depression Inventory (BDI-I) was used to measure depressive symptom severity during the past two weeks [22]. The scale consists of 21 items each answered on a 4-point Likert scale (score range:0-63), with higher scores representing more depressive symptoms.

### Anticipatory and consummatory anhedonia

The Temporal Experience of Pleasure Scale (TEPS) was used to measure anticipatory and consummatory experiences of pleasure [23]. It includes 20 items capturing four factors: consummatory contextual factor, consummatory abstract factor, anticipatory contextual factor and anticipatory abstract factor. Lower scores indicate higher levels of anhedonia.

### Data analysis

Multiple imputation was conducted to handle missing data. The number of imputations was increased until the fraction of missing information/imputations  $M=0.1$  reached a value which was  $<10\%$  of the standard error of the estimate. 50 imputations were sufficient to meet this criterion in present study. All data ( $n=345$ ) included in the following analysis. Firstly, to assess the potential impact of the pandemic, the multivariate linear mixed model was used to examine the overall change in consummatory and anticipatory anhedonia, and depression over time. Bonferroni multiple comparison was used. Partial Eta Squared ( $\eta^2$ ), an effect size index, was reported for symptom changes,  $\eta^2=0.01, 0.06$  and  $0.14$  are considered small, medium and large, respectively. Secondly, interactions between time and different predefined subgroups pre-lockdown were used to identify heterogeneity in the effects of Covid-19 pandemic on anticipatory and consummatory anhedonia. The mean of from T1 to T3 was used for pre-lockdown data. Demographic subgroups included gender, place of residence, household income, family history of mental health illness, pre-existing psychiatric disorders, smoking, drinking, suicidal ideation and previous suicide attempt. Five types of child maltreatment such as emotional neglect, physical neglect, emotional abuse, sexual abuse, and physical abuse were transformed respectively into a categorical variable with "absent" and "present" groups. Depression and COVID related stress as continuous variable were entered the model. All tests were two-tailed, with a significance level of  $p<.05$ . Statistical analysis was performed using SPSS 27.0 [24].

## Results

### Descriptive statistics

Figure 2 presents the proportions at the item level of the COVID-19 related stressor measure. The most commonly stressful area (above severe) during lockdown was schools being closed (33.6%), remote learning (22.3%), and lack of PPE supplies (17.1%). Significant higher anticipatory anhedonia at baseline were observed for individuals who reported emotional abuse ( $t(344)=-2.31, p=.022$ ) and male participants ( $t(344)=-2.60, p=.01$ ). No significant difference was observed for other demographic and child maltreatment subgroups. There was also no difference in consummatory anhedonia among all subgroups.

The results of the multivariate mixed linear model analyses are shown in Table 1. The main effect of time was significant, showing a decrease in the scores for anticipatory and consummatory anhedonia. Bonferroni-corrected pairwise post-hoc comparisons showed, compared with pre-lockdown (T1-T3), anticipatory and consummatory pleasure were significantly increased from the beginning of the national lockdown to 10 months post-lockdown, but no change was found between during- and post-lockdown (from T4-T7), see Figure 3 and Table 2. The same improvement pattern was found in depression, with a significant decrease in the scores from before to the initial outbreak, to easing of lockdown, to 7 months after lockdown, and to 10 months after lockdown.

**Table 1.** Multivariate mixed model examining the predictors for outcomes across lockdown.

	Anticipatory pleasure	Consummatory pleasure
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	Estimate	t	p	95% CI	Estimate	t	p	95% CI
Interactions with time (difference in change from T1 to T7)								
Anticipatory pleasure	38	80.16	<.001	37.07, 38.93	-	-	-	-
Consummatory pleasure	-	-	-	-	43.88	92.55	<.001	42.95, 44.81
Time	-1.47	-2.68	0.007	-2.54, -0.39	-1.58	-2.88	0.004	-2.65, -0.50
Drinking (no)	0.07	0.38	0.702	-0.27, 0.41	0.04	0.23	0.816	-0.30, 0.38
Smoking (no)	0.24	0.87	0.382	-0.30, 0.79	0.34	1.22	0.224	-0.21, 0.89
Family history (no)	-0.02	-0.06	0.952	-0.55, 0.51	0.17	0.64	0.52	-0.36, 0.70
Gender (female)	0.35	2.04	0.042	0.01, 0.70	0.48	2.78	0.006	0.14, 0.83
Household income (rich)	0.29	1.96	0.05	0, 0.58	0.33	2.24	0.025	0.04, 0.62
Pre-pandemic disorders (yes)	-0.6	-2.08	0.038	-1.16, -0.03	-0.86	-2.99	0.003	-1.42, -0.30
Residency (city)	0.09	0.69	0.489	-0.17, 0.35	0.09	0.65	0.517	-0.17, 0.35
Previous suicide attempt(no)	-0.13	-1	0.317	-0.38, 0.12	-0.1	-0.81	0.419	-0.35, 0.15
Self-harm (no)	0.11	0.45	0.654	-0.37, 0.59	-0.17	-0.67	0.501	-0.65, 0.32
Emotional abuse (no)	0.54	1.61	0.108	-0.12, 1.2	0.88	2.62	0.009	0.22, 1.54
Emotional neglect (no)	0.4	2.15	0.032	0.03, 0.76	0.26	1.43	0.153	-0.10, 0.63
Physical neglect (no)	-0.03	-0.15	0.884	-0.39, 0.34	0.05	0.28	0.781	-0.31, 0.42
Physical abuse (no)	0.01	0.04	0.969	-0.63, 0.65	0	0	0.996	-0.64, 0.64
Sexual abuse (no)	0.59	1.68	0.093	-0.10, 1.28	0.63	1.78	0.075	-0.06, 1.31
COVID-19 related stressor	0.02	3.1	0.002	0.01, 0.03	0.02	3.37	0.001	0.01, 0.03
BDI17	-0.08	-6.97	<.001	-0.10, -0.05	-0.06	-5.68	<.001	-0.08, -0.04

BDI17=the Beck Depression Inventory scale, deleted 4 items associated with anhedonia; Emotional and physical abuse, sexual abuse, emotional and physical neglect: with respectively 13, 10, 8, 15 and 10 score or more indicating a clinically significant level (present).

**Table 2.** Repeated ANOVA analysis for depression and anhedonia.

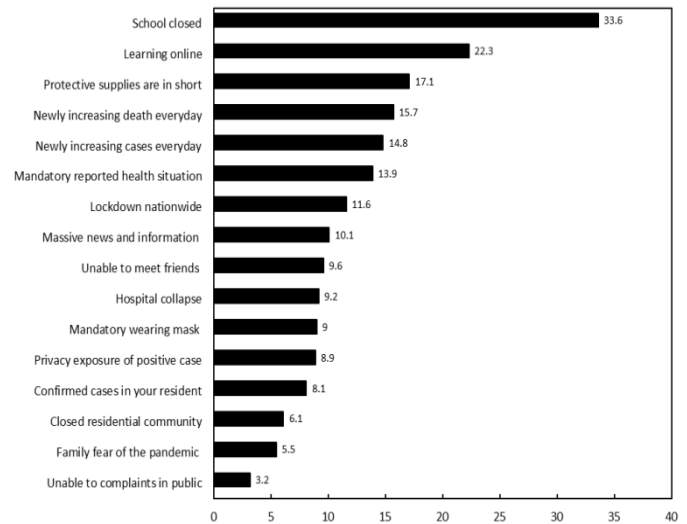
Variables	Time	Mean	SD	F	p	$\eta^2$	Bonferroni contrasts
Depression	T1	7.47	7.19	8.21	<.001	0.02	T4=T5=T6=T7<T1=T2=T3
	T2	6.77	6.09				
	T3	6.82	8.95				
	T4	4.88	7.73				
	T5	4.45	8.06				
	T6	4.44	7.43				
	T7	4.91	8.67				
Anticipatory anhedonia	T1	37.06	6.37	10.13	<.001	0.03	T1=T2=T3; T4=T5=T6=T7;
	T2	37.16	6.13				
	T3	37.78	6.86				
	T4	39.48	7.17				
	T5	39.48	7.69				
	T6	39.18	7.1				
	T7	39.88	7.61				
Consummatory anhedonia	T1	43	7.6	9.98	<.001	0.02	T1=T2=T3; T4=T5=T6=T7;
	T2	43.61	7.27				
	T3	44.14	8.32				
	T4	45.49	8.37				
	T5	46.22	8.75				
	T6	45.54	7.96				
	T7	46.65	8.4				

Pre-lockdown: T1: 2018.10; T2: 2018.12; T3: 2019.09.

During lockdown: T4: 2020.02, the fourth week of lockdown; T5: 2020.04, the easing of lockdown.

Post-lockdown; T6: 2020.09, 8 months after lockdown. T7: 2020.12, 10 months after lockdown.

To further examine difference change in consummatory and anticipatory anhedonia associated with the pandemic between different vulnerable subgroups, the interaction of time with a set of predefined risk factors were entered the multivariate mixed linear model. As shown in Table 1, having a pre-existing mental health condition, living in a lower-income household, being male were associated with a less decrease in anticipatory and consummatory anhedonia. Individual with emotional neglect showed a less decrease in anticipatory anhedonia whereas those with emotional abuse showed a less decrease in consummatory anhedonia. Depressive symptom positively predicted anticipatory and consummatory anhedonia whereas COVID-19 relative stressors negatively predicted anticipatory and consummatory anhedonia. No meaningful difference was observed for other subgroups, including place of residence, family history of mental health illness, smoking, alcohol consumption, suicidal ideation, previous suicidal attempt, physical neglect, physical abuse, and sexual abuse.

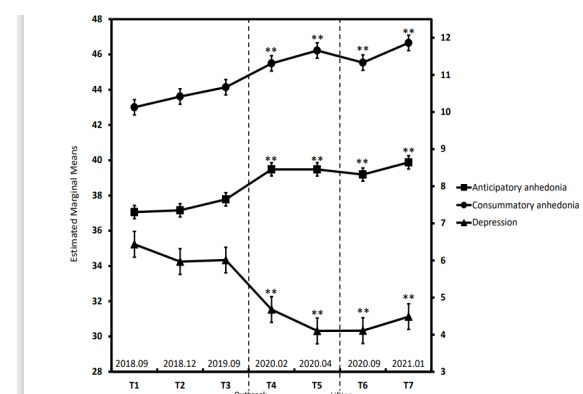


**Figure 2.** The proportions at the item level of the COVID-19 related stressors

Supplemental Text 1

COVID 2019 stressful events was used to evaluate stress experienced due to lockdown restrictions. The following 17 items were developed as causes of stress :

- restrictions on the free movement of citizens,
- mandatory testing of temperature and wearing masks in public,
- closed residential community,
- unable to meet friends and relatives,
- widespread news and information about the new virus,
- mandatory reporting of health situation every day,
- privacy exposure,
- lack of supplies of Personal Protective Equipment (PPE) i.e. masks or protective clothes,
- healthcare workers infection and risk of hospitals being overwhelmed,
- school closures,
- learning online rather than face-to-face,
- being unable to complain about lockdown restrictions
- friends and family being diagnosed,
- confirmed cases in your area,
- family's fears of COVID-19 disease,
- increasing daily incidence,
- increasing daily death toll.



**Figure 3.** Positive changes of anhedonia and depression from October 2018 to December 2020

The Primary axis is anticipatory and consummatory pleasure whereas the Secondary axis is depression. \*\* Bonferroni correction p<.01, compared with pre-lockdown. Data shows estimated marginal means and standard error.

## Discussion

Contrary to our expectation, the present study found anticipatory and consummatory anhedonia showed marked improvement following an initial jump at the beginning of the lockdown and a subsequent stabilization after lockdown. Similarly, the improvement of depressive symptom occurred immediately following the national lockdown, but also over time, 10 months later compared with previous trend in 2018 and 2019. These results suggested that the short- and long-term impact of the lockdown contributed to improved emotional wellbeing in university students living in China, potentially highlighting their surprising resilience and psychological growth during the difficult and stressful period.

In contrast to studies revealing no overall change or an average increase in anhedonia during the COVID-19 pandemic, there was significant decrease in anhedonia and depression during the national lockdown among university students [25]. Positive psychology proposes that adversity is not necessarily going to be all negative; individuals still can cultivate joy and love in challenging times [26]. For example, 80% Chinese students in primary and secondary school were satisfied with their life status during lockdown, and 21.4% of participants became more satisfied with life compared to before the previous year [27]. Similarly, over 56% of adult participants experienced more grateful than usual [28], and 61% of front-line healthcare workers reported an astonishing increase in job satisfaction because they found a higher meaning and purpose in their work. Moreover, people could take advantage of this lockdown as an unexpected catalyst to cultivate positive changes in their multiple aspects of life outcomes. In China, both adolescents and adults reported positive changes in various life outcomes including reduced aggressive behaviour, less drinking and smoking, over the national lockdown period. Similar observations emerged in Scotland and Australia, people experienced many positive changes in social patterning: having the opportunity to spend more time with family, doing more enjoyable things, appreciating more flexible work practices, and enjoying a less busy and quiet lifestyle [29]. Similarly, some families also reported positive benefits and meaning: an increased willing to express emotions, being kindness, and experiencing appreciation, joy, and tolerance [30]. Besides, individual may use the crisis in a transformative way to develop new cope strategies, leading to marked psychological improvement [31]. For instance, adolescents developed positive cope strategies after COVID-19 lockdown, including successfully dealing with uncertainty, learning not to be bothered by small hassles, discovering one's inner strength, and becoming more accepting of self and others. In Hong Kong, people reported many positive and adaptive responses to the pandemic such as an increased attitude to take new paths in life or showing more likely help to others [32]. This diverse set of coping strategies has the ability to facilitate one or more pleasure experience/positive emotions, such as contentment, happiness, love, gratitude, and hope [33]. Importantly, some surprising mental health benefits have found during the pandemic. For example, a study from French found that the majority of people did not panic, quite the contrary, they declared feeling healthier and having a better psychological well-being than before pandemic [34,35]. Chinese adolescents also reported a significant decrease in depression, insomnia symptom and sleep problems during home confinement and continued to decline after the lifting of lockdown [36]. In recent studies by our group, secondary students reported a significant decrease in different types of child maltreatment during lockdown. For university students, the lockdown restrictions stimulated increased their psychological resilience decreased perceived stress and depressive improvement in short- and long-term [37]. Some major external stressors, such as the Great East Japan Earthquake, researchers were surprised by what they found: an improvement of overall morale in young people rather than the expected decline compared with before the disaster [38]. This converging evidence highlight that most individuals have been either largely unaffected or are even doing better in face of the unprecedented pandemic [39].

One potential reason for such improvement in anhedonia may be linked to increase exposure to social affiliation interaction, sexual gratification and food enjoyment (natural rewards), resulting in activation in brain reward circuitry and increase in positive emotions [40]. Firstly, the acute effects of the pandemic triggered an initial boost in social affiliation, which can create enjoyable experiences (e.g. satisfactory, happiness, safety and warmth) because higher positive emotions scores often occur after the social affiliative interaction [41]. For example, some families benefitted from lockdown via engaging in enjoyable activities together, focusing on their relationship, and deepening their connection with their member, hence creating enhanced family cohesion [42]. Other families reported improved

parent-children relationship via sharing laughter, being loved and kind, and assisted in families reframing the negative experience to develop appreciation, patience, and amusement [43]. Secondly, strict lockdown measures appear to increase intimacy relationship more satisfaction on their romantic relationship and sexual gratification within a loving relationship [44]. Such increased relationship satisfactions as a source of enjoyment can facilitate more positive affiliative affect, more positive reactions to the interaction partner, and a greater willingness to interact with the partner in the future, potentially increasing positive emotions of contentment, pride, and excitement. Finally, it became evident that more food-based enjoyment was found during lockdown such as increased family mealtimes and family connectedness over food, leading to increased eating enjoyment, happiness or amusement [45]. In previous cross-international studies, people reported more enjoyment in cooking and eating, more time in selecting and preparing healthy food and more family meals [46-50]. It is, therefore, very likely that as people are experiencing these pleasant states, deepen their experience of receipt of reward (consummatory pleasure), which subsequently encourages the individual to seek more pleasant stimulus in the environment (anticipatory pleasure) [51-55], which in turn motivates people to approach and continue consuming enjoyable stimulus and activities at the moment [56]. The two types of pleasure experience build one another reciprocally and then increase positive emotions over time. With repeated experiences of positive emotions, people may literally transform themselves for the better, such as becoming more resilient individuals and enabling flexible and creative thinking, which expand and improve their ways of coping with a current stress [57].

The long-term improvement in anhedonia and depression over the pandemic also aligns with the broaden-and-build theory of positive emotions. In brief, this theory states that positive emotions undo negative emotional arousal, broaden thought-action repertoires in the moment [58]. Positive emotions if recurrent can build a range of personal resources (e.g., resilience, optimism, creativity, social support networks) over time that can help later to bounce back from a wide range of future stress. In other words, accumulative positive emotions not only make people feel good in the present, but also increase the likelihood that people will feel good in the future [59]. Evidence suggested that positive emotions help individuals become more resilient to adversity over time, as characteristic by finding positive meaning within problems and by taking broad perspectives on those problems [60,61]. People who have thrived in the face of crisis may learn new skills and knowledge, gain confidence and mastery in their abilities to cope with future stressful events, and further growth becomes more probable [62]. In our previous study, compared with pre- and during lockdown, psychological resilience increased but perceived stress decreased 10 months later among university students [63]. Other studies have found that adversarial growth was large in magnitude and can persist for a year or longer after the traumatic events [64]. Drawing on this past evidence, we speculated that the more frequent anticipatory and consummatory pleasure experienced by university students in the present study increased their positive emotions, promote discovery of novel and creative actions, ideas and social bonds, which in turn build students' personal resources that enabled flexible adaptation to school-related stressful experiences when returning school, showing the durable improvement in anhedonia and depression [65-71]. In addition, our results may be a culturally specific reaction in China. In Confucian thoughts, adversity is an opportunity for self-cultivation of virtues, potentially influencing students to become more appreciative, respectful, grateful, and patriotic during the COVID-19 crisis [72]. Indeed, compared to Euro-Canadian participants, Chinese people had stronger forbearance and perseverance on lockdown restrictions, and used more positive ways (e.g. more positive affect, higher optimism, and higher meaning presence) to respond to the pandemic [73]. Likewise, in education environment, Chinese students endure much more academic competition compared with Western universities because academic performance will sort them to eventually decide their future career [74]. School closure and lockdown may benefit to escape these negative pressures, as the slowing down of daily routines contribute to increased relaxation [75]. Extended lockdown gave students a chance to experience a greater amount of freedom, flexibility and autonomy over their lives, leading to more productive, satisfactory and happier with staying at home. Further research is needed to reveal differences and similarities in the way of people respond to COVID-19 across cultures [76].

As predicted, the present study found students who reported a pre-existing mental health condition, low family income, being male and higher

depressive symptoms had less decreases in anticipatory and consummatory anhedonia than those who did not. This is not surprising because lockdown had a greater effect on vulnerable populations with pre-existing poor conditions during the Covid-19 pandemic [77]. Unexpectedly, greater COVID-19 related stressors (acute stress) predicted more anticipatory and consummatory pleasure. As illustrated in Figure 2, students seemed not to panic by virus but concerned school closure and remotized learning. Possibly, for Chinese students, the pandemic is of moderate stress rather than toxic one. Tolerable stress is beneficial to increase psychological resilience and promote growth, as proposed by stress-related growth theory [78-80]. Individual with emotional neglect and abuse (early-life stress) showed less increases in anticipatory and consummatory pleasure, which is consistent with previous evidence. Different from sexual or physical abuse, anhedonia was related to specifically emotional neglect and abuse, which is consistent with previous findings showing emotional maltreatment were more profound than other types of childhood trauma in depression patients [81]. We also found that emotional neglect and abuse had different effects on two types of anhedonia: emotional abuse had effect on specific domains of consummatory anhedonia whereas emotional neglect was associated with anticipatory anhedonia. Previous study showed that emotional neglect was the unique risk in the approach system that underlies anticipation and motivation [82]. It may be that emotional neglect-exposure is more chronic in nature and stable over time compared to emotional abuse, which can cause the dopaminergic system dysfunction in the reward system related to anticipatory anhedonia [83]. On the other hand, emotional abuse-exposure may develop a positive emotion dysregulation due to a negative self-image and negative attributions (e.g., "I don't deserve to be happy"), which may cause an altered opioid sensitivity making it difficult to appreciate the online positive or enjoyable stimuli. Future research is needed to assess the precise mechanisms to elucidate this phenomenon.

## Conclusion

This study has a range of practical implications. Despite the abrupt changes in circumstances of the pandemic, it is also necessary to understand the potential to facilitate positive change. The present study revealed that the pandemic did not damage but enhance pleasure capacity. From a preventive perspective, recurrent expose to enjoyable activities in daily life may be the most powerful leverage point for developing better mental health. From a positive psychology perspective, teachers might cultivate positive emotions by assigning students to engage in their favourite pleasant activities, learning new rewarding activities, training them in relaxation and asking students to discuss their past best of times to mitigate the detrimental effects of stressful events.

## Limitations

Findings from the current study should be interpreted in the context of important limitations. First, our small sample limits the generalizability of the present findings. However, the current findings are still valuable and meaningful in that little research has specifically examined anhedonia changes during pandemic so far. Moreover, our seven-wave longitudinal design with is promising as it allows direct comparison across lockdown periods. Another limitation is the mostly female sample from a single university. However, given the acute nature and degree of changes COVID-19 brought about, changes in youth mental health are likely largely attributable to the events associated with the pandemic. Finally, the long-term duration of the zero-dynamic policy itself, which continues and is expected to go on for some time longer. The role that the duration of this policy plays on anhedonia is currently unknown. Future research may continue exploring whether pleasure capacity grows, stalls, or reverses as the policy continues. In conclusion, a silver lining shimmered within the dense cloud of anguish: pleasure capacity did not disappear but grow during the pandemic both in the short and long-term. The present findings strongly suggest that the pandemic's effect on student mental health has the positive side as well. Given that the current topic is crucial yet largely underexplored, we encourage future research to focus more on benefit finding and positive changes in future comparable crises.

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