# Associations between Recurrent COVID-19, Attention, and Mental Health: A Longitudinal Study

Mohammad Ahsan Khodami[1]*, Seyed Mohammad Hosseini[2], Seyran Bagheri[3], Sofia Kireeva[4]
[1]*Department of General Psychology, University of Padua, Italy*
[2]*Isfahan University of Technology, Isfahan, Iran*
[3]*Payam Noor University, Sanandaj, Iran*
[4]*Ural Federal University, Ekaterinburg, Russia*
***Corresponding author**: mohammadahsan.khodami@phd.unipd.it

**Abstract**
This two-part longitudinal study examined impacts of initial and recurrent COVID-19 diagnosis on negative affect and attention control in 296 undergraduate students during pandemic lockdowns. Study 1 found first-time diagnosis was associated with significantly higher depression, anxiety, and stress but did not affect attention control. Study 2 showed recurrent diagnosis further worsened mental health outcomes yet was linked to enhanced attentional abilities, contrasting typical condition declines. Within-subjects analysis demonstrated worsening affect but improvements in attention control from first to second timepoints among repeatedly diagnosed participants. Overall, both initial and recurrent diagnosis severely impact psychological wellbeing with cumulative mental health tolls, underscoring needs to prioritize supporting mental health. However, attentional resilience emerges, potentially reflecting an adaptive coping response. Continued research tracking patients across multiple infections can clarify relationships between worsening emotions and improved attention, informing interventions to address multifaceted health impacts of COVID-19 reinfection.

**Keywords**
COVID-19 — recurrent diagnosis — Attention — Mental Health — psychological wellbeing

## Introduction

## Introduction

The COVID-19 pandemic has intensely impacted mental health around the world. Numerous studies have empirically studied different aspects of COVID-19 on mental health, including stress and emotion [1], mental health functioning [2], psychiatric conditions [3], cognitive and sleep problems [4], and neuropsychiatric [5] across the globe. Most published studies estimate that most of the population has experienced pandemic-related psychological distress, including clinically significant anxiety and depression [6], Social isolation [7], economic hardship [8], health anxiety, uncertainty [9], and other pandemic stressors have been strongly linked to worsening stress, psychiatric symptoms, and quality of life [10].

A meta-analysis by [11] showed that 27% of patients with COVID-19 had attention disorders, 16% had memory loss, 13% had anxiety, 12% had depression, and 2% had mood disorders, which indicates that the impact of COVID-19 on mental health is severe. A study by [12] showed that neuropsychological deficits related to COVID-19 were seen in attention, memory, and executive function domains.

Critically understudied is the impact of COVID-19 on cognitive functions such as attention. Attention refers to processes allowing selective focus on specific information while filtering irrelevant inputs [13]. Core components of attention include sustained, selective, divided attention, and attentional control. Attention underlies most aspects of life, enabling effective learning, work, socializing, and routine tasks. Prior research has demonstrated that attention, like other psychological components that can be influenced by other factors [14], can be influenced by additional psychological factors. Specifically, attention has been shown to be altered in the context of psychological disorders, including stress [15], anxiety [16], and others that impact cognitive processes. The interrelationship between attention and various affective states underscores the malleability of attentional mechanisms in response to broader psychological worries.

Disruptions can substantially impair function [15]. Emerging data demonstrate attentional impairments in those recovering from COVID-19, including reduced psychomotor speed and deficits in sustained visual attention [17]. However, small portion of studies investigated the impact of recurring COVID-19 infections, although many have had multiple diagnosed illnesses as new variants emerge. While COVID-19 has been associated with

attentional deficits, limited number of research has yet investigated how pandemic-related psychological distress may interact with COVID-19 illness to exacerbate attention difficulties. Psychological stress is strongly hypothesized to degrade prefrontal cortical functions, including attentional control [18]. The profound psychosocial stressors of the COVID-19 pandemic could plausibly worsen any direct effects of COVID-19 infection on attention. To address these critical gaps, we conducted a longitudinal study assessing attention in individuals with multiple diagnosed COVID-19 infections.

We tested the following hypotheses:

**Hypothesis 1:** Individuals diagnosed with COVID-19 will exhibit higher levels of negative affect, including increased stress, anxiety, and depression, than nondiagnosed individuals.

**Hypothesis 2:** Increases in negative affect are associated with detrimental changes in attentional focus.

**Hypothesis 3:** Recurrent COVID-19 diagnosis will be related to a more significant exacerbation of negative affect and attentional focus disruptions than first-time diagnosis.

## 1. Power Analysis

A power analysis was conducted using G*Power 3.1.9.4 to determine the required sample size to adequately detect effects in the current repeated measures design. Based on the parameters of 2 groups (COVID-19 diagnosis vs. no diagnosis), 2 time points (T1 and T2), a medium effect size $f$ of 0.25, an alpha of 0.05, and power of 0.80, the recommended total sample size was 98 participants. This sample size target was determined to provide sufficient power to detect medium-sized differences between COVID-19 diagnosed and non-diagnosed groups across the two timepoints on the key outcome variables of negative affect and attention control. The obtained sample of 151 participants exceeds this minimum recommendation.

## 2. Study 1

### 2.1 Methods

#### 2.1.1 Participants

This two-part study recruited undergraduate students during COVID-19 lockdowns in Iran and Russia. In the first phase (T1), 296 students (130 Female, mean age 24.88 years, SD 3.62) were recruited via word-of-mouth and social media from March 1 to April 20, 2020, in Iran and April 1 to May 15, 2020, in Russia. Participants were assigned links to the study shared via QR codes, email, and messaging platforms. Participants received a random registration code.

### 2.2 Procedure

The study was conceived during early COVID-19 lockdowns through meetings between the authors. Links to the online study were disseminated via social media. In T1, recruited participants completed demographic questions, DASS-21, and ATTC. Participants could withdraw consent at any time.

#### 2.2.1 Questionnaires and survey data

The demographic data collected in this research included the initials of participants' first and last names (e.g., JD for John Doe), their age, gender (M/F), and whether they had been diagnosed with COVID-19 at the time of completing the questionnaire or before that date, confirmed verbally that they were diagnosed via either hospital test or PCR tests. The survey also captured whether participants were willing to participate in a follow-up study. If so, they were asked to provide contact details such as an email address, phone number, or other preferred method of communication for receiving the follow-up forms.

**Depression, Anxiety, and Stress Scale - DASS-21** The Depression, Anxiety, and Stress Scale-21 (DASS-21) [19, 20] is a shortened version of the original 42-item DASS developed by Lovibond and Lovibond (1995). The DASS-21 contains three 7-item subscales measuring symptoms of depression, anxiety, and stress. Brown et al. (1997) suggested that the DASS-21 subscales align with the tripartite model of anxiety and depression, measuring low positive affect (DASS-Depression), physiological hyperarousal (DASS-Anxiety), and negative affect (DASS-Stress). The tripartite model proposes that depression is characterized by low positive affect, anxiety is characterized by physiological hyperarousal, and negative affect is common to depressive and anxious symptoms.

**Attentional Control Scale - ATTC** The Attentional Control Scale (ATTC) [16] is a self-report questionnaire designed to measure individual differences in the ability to control attentional processes voluntarily. It consists of 20 items assessing three aspects of attentional control, including focusing, shifting attention between tasks, and controlling thought flexibly. The items are scored on a 4-point scale from "almost never" to "always." Higher scores indicate greater perceived attentional control. The scale was found to have good internal consistency and was negatively correlated with trait anxiety and negative emotionality measures. It was also validated against a task measuring the ability to inhibit dominant response tendencies. This suggests that the Attentional Control scale captures meaningful individual differences relevant to emotion regulation and coping.

## 3. Study 2

### 3.1 Methods

#### 3.1.1 Participants

To achieve the stated aims of investigating the effects of COVID-19 diagnosis on attention and negative affect, longitudinal follow-up data were collected between April 1 to April 20, 2021, in Iran and October 28-November 15, 2021, in Russia. Invitations to complete the second survey were sent to 296 original study participants (T1) who had indicated willingness for follow-up. Of these, 151 participants completed the second survey. Invitations were distributed based on the preferred contact methods provided initially. To confirm respondent identities, the survey platform prompted participants to verify basic information, including their initials (e.g., JD), age, and previous COVID-19 diagnosis status (Y/N) from the first study. After completing this identity confirmation step, participants were directed to the complete follow-up survey. Figure 1 shows the Data checking form to continue to the next step of study.

#### 3.1.2 Procedure

The procedure of the following study was the same as in study 1, but since our participants had already confirmed their demographics, they were asked to answer whether they were diagnosed with COVID-19 again; then, following this query, they were redirected to the questionnaire pages.

#### 3.1.3 Questionnaires and survey data

This section remained the same as the first study and we did not imply any change to these sections.

## 4. Statistical Analysis

We used R code to calculate the total score, attentional shift, and attentional focus based on the questionnaire detail provided [16]. Since the main package *lmsupport* had technical problems calculating *varScore*, we adopted the *varScore* code from the main package and rerun it to calculate the Attentional focus, shift and total attention score **See Appendix R code**. Rest of data analysis were done in Python using different packages.

## 5. Results

### 5.1 Study 1

In this stage, 296 participants completed the survey (130 females, 43.91% of the sample), with a mean age of 24.88(SD 3.62). Of these participants, 154 (52.03% of the sample) reported being diagnosed with COVID-19, while 142 (47.97%) reported no COVID-19 diagnosis.

#### 5.1.1 DASS-21 and COVID Analysis

The data obtained for all participants, **irrespective of COVID-19 diagnosis**, revealed a mean score of 11.97(SD 3.27) for DASS-D, 13.83(SD 4.65) on the DASS-A, and 9.25(SD 4.19) for DASS-S. Respected to the results based on COVID-19 diagnosis showed differences across some subscales, as presented in Table 1.

| | DASS-D | | DASS-S | | DASS-A | |
|---|---|---|---|---|---|---|
| COVID | Yes | No | Yes | No | Yes | No |
| Mean | 12.56 | 11.34 | 10.97 | 7.37 | 17.4 | 9.97 |
| SD | 3.63 | 2.69 | 4.33 | 3.09 | 1.69 | 3.62 |

**Table 1.** statistical descriptive analysis of DASS-21 Questionnaire

The data in Table 1 demonstrate that individuals diagnosed with COVID-19 reported significantly higher scores on all three subscales of the DASS-21 questionnaire compared to individuals not diagnosed with COVID-19. Specifically, the COVID-19 group showed higher mean levels of depressive symptoms (Mean=12.56, SD 3.63) than the non-COVID group (Mean=11.34, SD 2.69), greater mean anxiety symptoms (COVID Mean=17.4, SD 1.69; No COVID Mean=9.97, SD 3.62), and higher mean stress levels (COVID Mean=10.97, SD 4.33; No COVID Mean=7.37, SD 3.09). The difference between groups was most pronounced for anxiety. Overall, these results indicate that diagnosis of COVID-19 is associated with greater severity of negative emotional symptoms, especially anxiety, compared to those not diagnosed.

Pearson correlation analyses as shown in Table 2 revealed significant positive associations between COVID-19 diagnosis and scores on all three DASS-21 subscales, including strong correlations with anxiety ($r = 0.860$, $p < 0.001$) and moderate correlations with stress ($r = 0.500$, $p < 0.001$) and depression ($r = 0.172$, $p < 0.01$). These results indicate that diagnosis with COVID-19 is related to clinically significant increases in symptoms of anxiety, stress, and depression, with the strongest correlation emerging for anxiety. Additionally, the DASS-21 subscales were significantly intercorrelated, suggesting comorbidity between negative emotional states. In particular, anxiety showed moderate correlations with both depression ($r = 0.164$, $p < 0.001$) and stress ($r = 0.421$, $p < 0.001$). Taken together, these correlations provide robust evidence that contracting COVID-19 may profoundly impact mental health and underscore the need for psychological services to address the anxiety, stress, and depressive symptoms associated with this diagnosis.

| | COVID | DASS-A | DASS-D | DASS-S |
|---|---|---|---|---|
| COVID | 1 | | | |
| DASS-A | 0.860*** | 1 | | |
| DASS-D | 0.172** | 0.164*** | 1 | |
| DASS-S | 0.500*** | 0.421*** | 0.56 | 1 |
| * p <0.05, ** p <0.01, *** p <0.001 | | | | |

**Table 2.** Correlational table of COVID-19 and DASS questionnaire

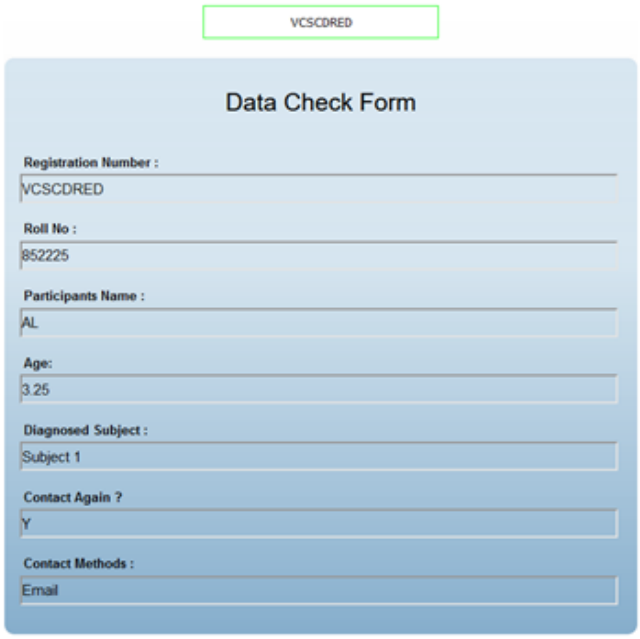


**Figure 1.** Demo of confirming data from participants were accessed with a link or access code; Diagnosed Subject: Subject 1 means participants were already diagnosed with COVID; Data entered in this figure are sample data.

Also, to have a better understanding, we have performed an ANOVA to have more detailistics. One-way ANOVAs revealed significant effects of COVID-19 diagnosis on depression, anxiety, and stress as measured by the DASS. On the depression subscale, the COVID-19 group had significantly higher scores than the non-COVID group ($F(1, 294) = 8.98, p = 0.003, \eta^2 = 0.03$). For anxiety, the COVID-19 group scored significantly higher than the non-COVID group ($F(1, 294) = 834.30, p < 0.001, \eta^2 = 0.74$). Similarly, the COVID-19 group had significantly higher stress scores compared to the non-COVID group ($F(1, 294) = 98.00, p < 0.001, \eta^2 = 0.25$). Overall, having a COVID-19 diagnosis was associated with greater depression, anxiety, and stress. Effect sizes were medium for depression and stress and large for anxiety.

#### 5.1.2 ATTC and COVID Analysis

Descriptive statistics were calculated for the Attentional Control Questionnaire (ATTC) subscales, including Attentional focus (ATTC-F), Attentional shift (ATTC-SHI), and Total Attentional Control (ATTC-Total) scores. The analysis was conducted on data from 296 participants. The mean ATTC-F score was 12.05 (SD 3.12), the mean ATTC-SHI score was 13.70 (SD = 3.84), and the mean ATTC-Total score was 25.75 (SD 5.02). It should be noted that the Total score represents the cumulative total of the AF and AS subscale scores. Table 3 provides these descriptive results provide baseline ATTC scores on this sample before examining differences based on COVID-19 diagnosis.

| | ATTC-F | | ATTC-SHI | | ATTC-Total | |
|---|---|---|---|---|---|---|
| COVID | Yes | No | Yes | No | Yes | No |
| Mean | 11.81 | 12.29 | 13.66 | 13.68 | 25.46 | 25.96 |
| SD | 3.10 | 3.01 | 3.90 | 3.76 | 5.16 | 4.50 |
| AF = ATTC Focus; AS = ATTC Shift; total = ATTC Total | | | | | | |

**Table 3.** statistical descriptive analysis of the ATTC Questionnaire

Table 3 displays the mean and standard deviation for the Focus, Shift, and Total scores on the Attention Control Scale (ATTC) for COVID-19 diagnosed and non-diagnosed groups. The COVID-19 group showed slightly lower mean Focus and Total ATTC scores compared to the non-COVID group, indicating worse attention control. The Shift subscale means were nearly identical between groups. Standard deviations were fairly similar between groups across all ATTC subscales, suggesting comparable variance. Overall, minimal differences emerged between COVID-19 and non-COVID groups on the attention control measure.

| | COVID | ATTC-F | ATTC-SHI | Total |
|---|---|---|---|---|
| COVID | 1 | | | |
| ATTC-F | -0.10 | 1 | | |
| ATTC-SHI | 0.01 | 0.03 | 1 | |
| ATTC-Total | -0.05 | 0.64*** | 0.78*** | 1 |
| * p <0.05, ** p <0.01, *** p <0.001 | | | | |

**Table 4.** Correlational table of COVID-19 and ATTC questionnaire

Table 4 displays Pearson correlations between COVID-19 diagnosis and scores on the Attention Control Scale (ATTC) subscales and total score. No significant correlations were found between COVID-19 status and any of the ATTC scores. The ATTC Focus subscale showed a strong positive correlation with the Total score (r = 0.64, p < 0.001) as did the Shift subscale (r = 0.78, p < 0.001). The Focus and Shift subscales were not significantly correlated. Overall, these results indicate no relationship between COVID-19 diagnosis and performance on the attention control measure. The significant intercorrelations between the ATTC subscales provide evidence for the validity of the scale.

One-way ANOVA showed no significant effect of COVID-19 diagnosis on ATTC Focus scores, $F(1, 294) = 2.75, p = 0.098$. Similarly, no significant differences between COVID-19 and non-COVID groups emerged for either the Shift subscale, $F(1, 294) = 0.04, p = 0.842$, or the Total ATTC score, $F(1, 294) = 0.78, p = 0.377$.

Mean Focus scores were slightly lower in the COVID-19 group (M = 11.81, SD = 3.10) compared to the non-COVID group (M = 12.29, SD = 3.01), with a small effect size ($\eta^2 = 0.01$). Shift and Total score means and standard deviations were highly similar between groups.

Overall, these results indicate that a diagnosis of COVID-19 is not associated with significant differences in performance on the Attention Control Scale or its subscales. This suggests attention control is not substantially impacted by COVID-19 status in this sample.

#### 5.1.3 Discussion

The current study aimed to examine the impacts of COVID-19 diagnosis on negative affect and attention control. In line with Hypothesis 1, results revealed that individuals diagnosed with COVID-19 reported significantly higher levels of stress, anxiety, and depressive symptoms compared to nondiagnosed individuals. These findings align with previous research indicating that contracting COVID-19 can profoundly impact mental health due to factors like isolation, uncertainty, and health concerns [6, 21].

Notably, the difference between diagnosed and non-diagnosed groups was most pronounced for anxiety, with a large effect size. This highlights that anxiety may be particularly exacerbated by COVID-19, likely due to fears over health and contamination [22, 23]. Given the magnitude of these mental health impacts, providing psychosocial support and services to those facing COVID-19 diagnosis appears critical.

In contrast to Hypothesis 2, COVID-19 diagnosis did not correlate with significant disruptions in attentional control based on the Attention Control Scale. The groups showed minimal differences on focus, shifting, and total attention control. This diverges from some studies finding decrements in cognitive functioning like attention in COVID-19 patients [24, 25]. However, others have also found limited cognitive impact of COVID-19 [26], particularly for individuals with less severe illness not requiring hospitalization[27]. Most participants in the current study likely had relatively mild COVID-19, which may explain the lack of attention control differences. Further research should examine links between COVID-19 severity and attention abilities.

### 5.2 Study 2

In this study, 151 participants completed the survey (80 females, 52.98% of the sample), with a mean age of 24.88 years (SD 3.62). Of these participants, 64 (42.38% of the sample) reported having been diagnosed with COVID-19 again (recurrent COVID-19), while 87 (57.61% of the sample) reported no new COVID-19 diagnosis.

#### 5.2.1 DASS-21 and Re-COVID

descriptive statistics were conducted on DASS-21 subscale scores for the entire sample, irrespective of COVID-19 diagnosis. Results revealed a mean depression score of 15.59 (SD 6.96), a mean anxiety score of 13.73 (SD 4.19), and a mean stress score of 16.94 (SD 8.84). These provide baseline DASS scores for the sample. As shown in Table 5, group differences emerged across the subscales. The COVID-19 diagnosed group showed markedly higher mean depression (M = 20.64, SD 4.21), anxiety (M = 16.84, SD = 2.16), and stress (M = 23.36, SD 5.67) scores compared to the non-diagnosed group (depression: M = 8.72, SD 2.83; anxiety: M = 9.50, SD 1.97; stress: M =8.22, SD 3.09).

| | DASS-D | | DASS-S | | DASS-A | |
|---|---|---|---|---|---|---|
| COVID | Yes | No | Yes | No | Yes | No |
| Mean | 20.64 | 8.72 | 23.36 | 8.22 | 16.84 | 9.50 |
| SD | 4.21 | 2.83 | 5.67 | 3.09 | 2.16 | 1.97 |

**Table 5.** statistical descriptive analysis of DASS-21 Questionnaire

A Pearson correlation analysis was conducted to assess the relationships between COVID-19 diagnosis and scores on the DASS-21 subscales (Table 6). Results revealed strong significant positive correlations between COVID-19 diagnosis and depression (r = 0.849, p < 0.001), anxiety (r = 0.869, p < 0.001), and stress (r = 0.849, p < 0.001). This indicates that a diagnosis of COVID-19 is associated with considerably higher levels of negative emotional symptoms across all three domains assessed by the DASS-21.

Additionally, the DASS-21 subscales were intercorrelated, with the strongest correlations occurring between anxiety and depression (r = 0.713, p < 0.001) and anxiety and stress (r = 0.779, p < 0.001). These interrelationships suggest a comorbidity between negative affective states, which aligns with prior research on associations between depression, anxiety, and stress. Overall, these robust

correlations provide further evidence that contracting COVID-19 has profound detrimental impacts on mental health, particularly anxiety.

| | COVID | DASS-A | DASS-D | DASS-S |
|---|---|---|---|---|
| COVID | 1.000 | | | |
| DASS-A | 0.869*** | 1.000 | | |
| DASS-D | 0.849*** | 0.713*** | 1.000 | |
| DASS-S | 0.849*** | 0.779*** | 0.718*** | 1.000 |
| * p < 0.05, ** p < 0.01, *** p < 0.001 | | | | |

**Table 6.** Correlational table of COVID-19 and DASS questionnaire

One-way ANOVA revealed a significant effect of COVID-19 diagnosis on depression (DASS-D) scores, $F(1, 149) = 385.09, p < 0.001, \eta^2 = 0.72$. Post-hoc Tukey tests showed the COVID-19 group had significantly higher DASS-D scores than the non-COVID group ($p < 0.001$). A significant effect of COVID-19 diagnosis was also found for anxiety (DASS-A) scores, $F(1, 149) = 459.70, p < 0.001, \eta^2 = 0.76$. Post-hoc tests indicated higher DASS-A scores in the COVID-19 versus non-COVID group ($p < 0.001$). Similarly, the COVID-19 group had significantly elevated stress (DASS-S) scores compared to the non-COVID group, $F(1, 149) = 385.38, p < 0.001, \eta^2 = 0.72$. Post-hoc tests confirmed this difference ($p < 0.001$).

#### 5.2.2 ATTC and ReCOVID Analysis

Like the first study, we ran a descriptive statistics for Attentional Control Scale (ATTC) subscales. The mean for whole population **irrespective to COVID diagnosis** for ATTC-F was 11.76(SD 3.17), for ATTC-SHI was 17.93(SD 5.59), and for ATTC-Total was 29.70(SD 7.47). Table 7 shows Mean and SD for this study based on diagnosis.

| | ATTC-F | | ATTC-SHI | | ATTC-Total | |
|---|---|---|---|---|---|---|
| COVID | Yes | No | Yes | No | Yes | No |
| Mean | 13.14 | 9.89 | 21.55 | 13.02 | 34.69 | 22.91 |
| SD | 2.93 | 2.44 | 3.39 | 4.02 | 4.71 | 4.63 |
| AF = ATTC Focus; AS = ATTC Shift; total = ATTC Total | | | | | | |

**Table 7.** statistical descriptive analysis of the ATTC Questionnaire

Table 7 displays means and standard deviations for the Focus, Shift, and Total subscale scores on the Attention Control Scale (ATTC) based on COVID-19 diagnosis status. The COVID-19 diagnosed group showed higher mean Focus (M = 13.14, SD = 2.93), Shift (M = 21.55, SD = 3.39), and Total (M = 34.69, SD = 4.71) ATTC scores compared to the non-diagnosed group (Focus: M = 9.89, SD = 2.44; Shift: M = 13.02, SD = 4.02; Total: M = 22.91, SD = 4.63). This pattern suggests that individuals diagnosed with COVID-19 report better attentional control abilities than non-diagnosed individuals in this sample. Standard deviations were fairly similar between groups.

| | COVID | ATTC-F | ATTC-SHI | Total |
|---|---|---|---|---|
| COVID | 1.000 | | | |
| ATTC-F | 0.508*** | 1.000 | | |
| ATTC-SHI | 0.756*** | 0.409*** | 1.000 | |
| ATTC-Total | 0.782*** | 0.730*** | 0.922*** | 1.000 |
| * p < 0.05, ** p < 0.01, *** p < 0.001 | | | | |

**Table 8.** Correlational table of COVID-19 and ATTC questionnaire

Pearson correlations were conducted between COVID-19 diagnosis and scores on the ATTC subscales and total (Table 8). Results showed significant moderate to strong positive correlations between COVID-19 diagnosis and Focus (r = 0.508, p < 0.001), Shift (r = 0.756, p < 0.001), and Total (r = 0.782, p < 0.001) scores. This indicates that COVID-19 diagnosis is associated with better attentional control abilities as measured by the ATTC. Additionally, the ATTC subscales were intercorrelated, with Shift showing the strongest correlation with Total scores (r = 0.922, p < 0.001) and a moderate correlation with Focus (r = 0.409, p < 0.001). Focus and Total scores were also strongly correlated (r = 0.730, p < 0.001). These interrelationships provide evidence for the validity of the ATTC in assessing attentional control.

One-way ANOVA showed a significant effect of COVID-19 diagnosis on ATTC Focus scores, $F(1, 149) = 51.89, p < 0.001, \eta^2 = 0.26$. The COVID-19 group had significantly higher Focus scores than the non-COVID group based on post-hoc tests ($p < 0.001$). A significant difference between the COVID-19 and non-COVID groups was also found for the Shift subscale, $F(1, 149) = 199.32, p < 0.001, \eta^2 = 0.57$. Post-hoc comparisons confirmed the COVID-19 group scored higher ($p < 0.001$). Similarly, the COVID-19 group had significantly elevated ATTC Total scores compared to the non-COVID group, $F(1, 149) = 234.15, p < 0.001, \eta^2 = 0.61$. Post-hoc tests showed this difference was significant ($p < 0.001$).

#### 5.2.3 Discussion

The second study aimed to examine the impacts of recurrent COVID-19 diagnosis on negative affect and attention control. Aligning with Hypothesis 3, results revealed that individuals diagnosed with COVID-19 again showed markedly higher depression, anxiety, and stress compared to those without new diagnosis. This builds on Study 1 by suggesting that recurrent COVID-19 profoundly exacerbates negative emotions, rather than mental health improvements occurring between diagnoses. The cumulative toll of repeated isolation and health uncertainties appears to worsen psychological outcomes [20, 28].

Interestingly, recurrent diagnosis was associated with enhanced attentional control, diverging from typical medical condition cognitive declines. The COVID-19

group showed significant improvements across Focus, Shift, and Total ATTC scores compared to the non-diagnosed group. This contrasts Study 1 which found no attentional impact of first COVID-19 diagnosis.

One potential explanation is that greater life disruptions with recurrent diagnosis increased motivation and effort for attentional control as an adaptive coping mechanism, studies such as [29] mentioned that exposure to early caregiving instability can lead to both decrements and enhancements in cognitive control, with potential for adaptation. Also [30] showed that trait anxiety is associated with increased attentional distraction, suggesting a general enhancement of bottom-up processes involved in motivational significance detection; [31] mentioned that Recurrent stress may also have a beneficial effect on cognitive performance in some individuals, potentially inducing resilience.

These findings collectively support the idea that greater life disruptions and recurrent diagnosis can increase motivation and effort for attentional control as an adaptive coping mechanism. Alternatively, attentional enhancements may stem from COVID-19 neuroimmunological changes. Further research should explore these possibilities.

## 6. Analysis of COVID-ReCOVID participants

To examine within-subjects changes across the two time points, participants diagnosed with COVID-19 at both T1 and T2 (n=87) were matched via their unique codes. Descriptive statistics were calculated for this subset on the DASS and ATTC measures at each time point.

As shown in Table 9, all DASS subscales evidenced increases in mean scores from T1 to T2, reflecting worsening negative affect over time. Specifically, depression (DASS-D) increased from T1 (M=12.57, SD=3.84) to T2 (M=20.64, SD=4.21). Anxiety (DASS-A) changed minimally from T1 (M=17.57, SD=1.72) to T2 (M=16.84, SD=2.16). Stress (DASS-S) showed the largest increase, rising from T1 (M=11.05, SD=4.15) to T2 (M=23.36, SD=5.67).

| | DASS-D | | DASS-S | | DASS-A | |
|---|---|---|---|---|---|---|
| | T1 | T2 | T1 | T2 | T1 | T2 |
| Mean | 12.57 | 20.64 | 11.05 | 23.36 | 17.57 | 16.84 |
| SD | 3.84 | 4.21 | 4.15 | 5.67 | 1.72 | 2.16 |

**Table 9.** Descriptive Statistics for DASS Factors

In contrast, as shown in Table 10, ATTC means increased from T1 to T2, indicating improvements in attentional control over time. ATTC-F rose slightly from T1 (M=12.02, SD=3.09) to T2 (M=13.14, SD=2.93). Larger increases occurred for ATTC-SHI, from T1 (M=13.59, SD=3.98) to T2 (M=21.55, SD=3.39), and ATTC-Total, from T1 (M=25.61, SD=5.26) to T2 (M=34.69, SD=4.71).

| | ATTC-F | | ATTC-SHI | | Total | |
|---|---|---|---|---|---|---|
| | T1 | T2 | T1 | T2 | T1 | T2 |
| Mean | 12.02 | 13.14 | 13.59 | 21.55 | 25.61 | 34.69 |
| SD | 3.09 | 2.93 | 3.98 | 3.39 | 5.26 | 4.71 |

**Table 10.** Descriptive Statistics for ATTC Factors

Taken together, these results demonstrate a pattern of worsening mental health but enhanced attention control across the two time points for individuals diagnosed with COVID-19 at both T1 and T2.

Also, One-way repeated measures ANOVAs were conducted on each DASS and ATTC variable to examine changes from time 1 (T1) to time 2 (T2).

For ATTC-F, there was a significant effect of time, $F(1, 86) = 5.96, p = 0.016, \eta^2 = 0.03$. The ATTC-SHI subscale also showed a significant time effect, $F(1, 86) = 201.96, p < 0.001, \eta^2 = 0.54$, as did ATTC-Total scores, $F(1, 86) = 143.83, p < 0.001, \eta^2 = 0.46$.

Significant time effects were found for all DASS subscales - Depression: $F(1, 86) = 174.28, p < 0.001, \eta^2 = 0.50$; Anxiety: $F(1, 86) = 6.18, p = 0.014, \eta^2 = 0.03$; and Stress: $F(1, 86) = 266.68, p < 0.001, \eta^2 = 0.61$.

Post-hoc Tukey tests indicated statistically significant increases from T1 to T2 for ATTC-SHI, ATTC-Total, DASS-D, and DASS-S. The differences between time points for ATTC-F and DASS-A were not significant in the post-hoc comparisons.

Overall, these results demonstrate significant worsening of depression, stress, and anxiety symptoms coupled with improvements in attentional control abilities over time for repeatedly COVID-19 diagnosed individuals.

### 6.1 Discussion

The within-subjects analysis examining participants diagnosed with COVID-19 at both time points provides further insight into the impacts of recurrent diagnosis. Aligning with Hypothesis 3, the results demonstrate a clear worsening of negative affect over time in this subgroup. As shown in Table 9, all three DASS measures increased from T1 to T2, although the increase was less pronounced for anxiety. Repeated ANOVA results revealed significant time effects for depression ($F(1, 86) = 174.28, p < 0.001, \eta^2 = 0.50$), stress ($F(1, 86) = 266.68, p < 0.001, \eta^2 = 0.61$) and anxiety ($F(1, 86) = 6.18, p = 0.014, \eta^2 = 0.03$).

These findings indicate the cumulative toll of recurrent COVID-19 diagnosis, with multiple experiences of isolation, health uncertainty, and other pandemic impacts exacerbating mental health declines. This contrasts typical recovery patterns and underscores needs for psychological support.

However, as shown in Table 10, attentional control improved over time in this subgroup, with significant ANOVA time effects for the ATTC-SHI subscale

($F(1, 86) = 201.96, p < 0.001, \eta^2 = 0.54$) and Total score ($F(1, 86) = 143.83, p < 0.001, \eta^2 = 0.46$). Focus also increased, though not significantly. This diverges as we already discussed in Section 5.2.3 from typical medical condition cognitive declines, suggesting attentional enhancements may act as an adaptive coping mechanism against the distress of repeated COVID-19 diagnosis. Alternatively, neuroimmunological changes could play a role. Further research should clarify these mechanisms and relationships between the worsening affective symptoms and improvements in attention.

These within-subjects results provide robust evidence that recurrent COVID-19 magnifies detrimental mental health outcomes but may simultaneously sharpen attentional control capacities, though poor emotional wellbeing could undermine any cognitive benefits. Longitudinal data tracking patients across multiple diagnoses is needed to expand on these findings.

## 7. General Discussion

This research aimed to investigate the impacts of COVID-19 diagnosis on negative affect and attention control, both initially and with recurrence. Aligning with Hypothesis 1, Study 1 found that first-time COVID-19 diagnosis was associated with significant exacerbations in depression, anxiety, and stress compared to nondiagnosed individuals, which this is align with studies like [6, 32, 33] However, attention control was unaffected, diverging from Hypothesis 2.

Study 2 provided initial evidence that recurrent COVID-19 diagnosis further magnifies detrimental mental health outcomes (Hypothesis 3), with participants diagnosed again showing markedly worse depression, anxiety, and especially high stress compared to those without new diagnosis, this evidence is also aligned with [34, 35]. Interestingly, recurrent diagnosis was linked to enhanced attentional abilities, contrasting typical medical condition cognitive declines, though this is not aligned with studies mainly, but also [36] have shown the same results.

The within-subjects analysis offered additional insights, demonstrating worsening of negative affect coupled with improvements in attentional control from T1 to T2 for repeatedly diagnosed individuals. This pattern indicates the cumulative toll of repeated COVID-19 diagnosis on mental health, while also suggesting attentional enhancements may act as an adaptive coping response.

Overall, these findings highlight that both initial and recurrent COVID-19 diagnosis profoundly impact psychological wellbeing, with anxiety particularly affected. Supporting mental health and providing psychosocial services should be priorities amid this pandemic. However, the resilience of attention control abilities provides some reassurance regarding cognitive functioning. Continued research tracking patients across multiple diagnoses and clarifying mechanisms is warranted. Elucidating relationships between worsening affect and improved attention will inform interventions to support the full range of health impacts for those facing COVID-19 reinfection.

## 8. Data Availability

Fully processed data cannot be shared sue to privacy concerns but it is available due to reasonable request to correspond author. Codes which are used for this work are available, **R code is available here**, also **Full python codes is available here** are available.

## 9. Limits of this study

While this study provides valuable initial evidence for the psychological impacts of recurrent COVID-19 infection, the conclusions are restricted by limitations in the samples and methods. The participants were exclusively undergraduate students within narrow age ranges and two specific countries. The generalizability of findings to broader populations is therefore limited. Additionally, the study relied solely on self-report measures and lacked comparison groups to control for potential influences of pandemic-related stressors. The causes of the observed changes also cannot be definitively attributed to COVID-19 recurrence alone. Finally, the longitudinal timeframe may have been insufficient to fully characterize longer-term effects. Future research with more diverse samples, objective measures, control groups, and extended follow-up periods is needed to confirm and expand on these preliminary results. Despite these limitations, this study offers important first evidence to motivate further investigation of cumulative impacts with repeated COVID-19 infection.

## 10. Ethical Approvals and Consents

This study was conducted in accordance with the Declaration of Helsinki, Online informed consent was obtained from individuals who participated in this study

## Acknowledgments

Authors would like to appreciate support, and contribution to all the students from universities who helped us during the acute-phase of pandemic. We also would like to appreciate contribution from Prof. Luca Battaglini, Giulio Contemori Ph.D. From university of Padua, and all other people who helped us sharing links and obtaining participants for this study.

## 11. Funding

Mohammad Ahsan Khodami, has recieved fund from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie

grant agreement No 101034319 and from the European Union – NextGenerationEU, Other authors declare of no fundings.

## 12. Conflic of Interests

Authors declare no conflict of interest

## References


[1] Antonio J Rodríguez-Hidalgo, Yérali Pantaleón, Ignacio Dios, and Dimitri Falla. Fear of covid-19, stress, and anxiety in university undergraduate students: A predictive model for depression. *Frontiers in Psychology*, 11:591797, November 2020.

[2] Emily Kroska. Psychological flexibility in the context of covid-19 adversity: Associations with distress. *Journal of Contextual Behavioral Science*, 18:28–33, 2020.

[3] Ryan A Serafini. Psychological distress in the face of a pandemic: An observational study characterizing the impact of covid-19 on immigrant outpatient mental health. *Psychiatry Research*, 2020.

[4] Shu-Wen Liang et al. The psychological impact of the covid-19 epidemic on guangdong college students: The difference between seeking and not seeking psychological help. *Frontiers in Psychology*, 11, 2020.

[5] Saurabh Kumar. Neuropsychiatric and cognitive sequelae of covid-19. *Frontiers in Psychology*, 12, 2021.

[6] Mohammad Ahsan Khodami, Mohammad Hassan Seif, Roya Sadat Koochakzadeh, Reza Fathi, and Harmeet Kaur. Perceived stress, emotion regulation and quality of life during the covid-19 outbreak: A multi-cultural online survey. *Annals of Medical and Psychology*, 180(6):514–518, June 2022.

[7] Maria Loades. Rapid systematic review: The impact of social isolation and loneliness on the mental health of children and adolescents in the context of covid-19. *Journal of the American Academy of Child and Adolescent Psychiatry*, 59:1218–1239.e3, 2020.

[8] Qing He et al. The impact of covid-19 on stock markets. *Economics and Political Studies*, 8:275–288, 2020.

[9] Firat Bakioglu et al. Fear of covid-19 and positivity: Mediating role of intolerance of uncertainty, depression, anxiety, and stress. *International Journal of Mental Health and Addiction*, pages 1–14, 2020.

[10] Amir Homayuni et al. Investigating the correlation between perceived stress and health anxiety with obsessive–compulsive disorder and quality of life during covid-19 pandemic. *BMC Psychology*, 11(1):54, February 2023.

[11] S Lopez-Leon et al. More than 50 long-term effects of covid-19: a systematic review and meta-analysis. *Scientific Reports*, 11(1):1–9, August 2021.

[12] Manuel Almeria, Juan Carlos Cejudo, Juan Sotoca, Joan Deus, and Jerzy Krupinski. Cognitive profile following covid-19 infection: Clinical predictors leading to neuropsychological impairment. *Brain Behavior and Immunity - Health*, 9:100163, December 2020.

[13] Michael I Posner, Mervin J Nissen, and Raymond M Klein. Visual dominance: an information-processing account of its origins and significance. *Psychological Review*, 83(2):157, 1976.

[14] Hadar Braunstein-bercovitz. Does stress enhance or impair selective attention? the effects of stress and perceptual load on negative priming. *Anxiety Stress Coping*, 16(4):345–357, December 2003.

[15] Frances C Fortenbaugh et al. Sustained attention across the life span in a sample of 10,000: Dissociating ability and strategy. *Psychological Science*, 26(9):1497–1510, September 2015.

[16] Douglas Derryberry and Maureen A Reed. Anxiety-related attentional biases and their regulation by attentional control. *Journal of Abnormal Psychology*, 111(2):225–236, May 2002.

[17] Dan J Graham and Christina A Roberto. Evaluating the impact of u.s. food and drug administration–proposed nutrition facts label changes on young adults' visual attention and purchase intentions. *Health Education & Behavior*, 43(4):389–398, August 2016.

[18] Jessica McKlveen. Chronic stress increases prefrontal inhibition: A mechanism for stress-induced prefrontal dysfunction. *Biological Psychiatry*, 80:754–764, 2016.

[19] Tian PS Oei, Sukanlaya Sawang, Yong Wah Goh, and Firdaus Mukhtar. Using the depression anxiety stress scale 21 (dass-21) across cultures. *International Journal of Psychology*, 48(6):1018–1029, 2013.

[20] Mohammad Ahsan Khodami and Laleh Sheibani. An investigation on negative activity, alexithymia, emotion regulation, and internet addiction in a sample of high school students: A randomized controlled trial. *Annals of Medical and Psychology*, 178(6):624–631, June 2020.

[21] Jiaqi Xiong, Orly Lipsitz, F. Nasri, L. Lui, H. Gill, Lee Phan, David Chen-Li, M. Iacobucci, R. Ho, Amna Majeed, and R. McIntyre. Impact of covid-19 pandemic on mental health in the general population: A systematic review. *Journal of Affective Disorders*, 277:55 – 64, 2020.

[22] Wenhui Lu, Han i Wang, Yuxing Lin, and Li Li. Psychological status of medical workforce during the covid-19 pandemic: A cross-sectional study. *Psychiatry Research*, 288:112936 – 112936, 2020.

[23] G. Asmundson, Michelle M. Paluszek, Caeleigh A. Landry, G. Rachor, D. McKay, and Steven Taylor. Do pre-existing anxiety-related and mood disorders differentially impact covid-19 stress responses and coping? *Journal of Anxiety Disorders*, 74:102271 – 102271, 2020.

[24] J. Twenge and T. Joiner. U.s. census bureau-assessed prevalence of anxiety and depressive symptoms in 2019 and during the 2020 covid-19 pandemic. *Depression and Anxiety*, 37:954 – 956, 2020.

[25] M. L. Reinholdt-Dunne, K. Mogg, and B. Bradley. Attention control: Relationships between self-report and behavioural measures, and symptoms of anxiety and depression. *Cognition and Emotion*, 27:430 – 440, 2013.

[26] Cristina Delgado-Alonso, M. Valles-Salgado, Alfonso Delgado-Álvarez, M. Yus, N. Gómez-Ruiz, M. Jorquera, Carmen Polidura, M. J. Gil, A. Marcos, J. Matías-Guiu, and J. Matías-Guiu. Cognitive dysfunction associated with covid-19: A comprehensive neuropsychological study. *Journal of Psychiatric Research*, 150:40 – 46, 2021.

[27] C. Olezene, E. Hansen, Hannah K Steere, J. Giacino, Ginger Polich, J. Borg-Stein, R. Zafonte, and J. Schneider. Functional outcomes in the inpatient rehabilitation setting following severe covid-19 infection. *PLoS ONE*, 16, 2021.

[28] J. Henssler, F. Stock, J. van Bohemen, H. Walter, A. Heinz, and Lasse Brandt. Mental health effects of infection containment strategies: quarantine and isolation—a systematic review and meta-analysis. *European Archives of Psychiatry and Clinical Neuroscience*, 271:223 – 234, 2020.

[29] Andrea Fields, Paul A. Bloom, Michelle VanTieghem, Chelsea Harmon, Tricia Choy, Nicolas L. Camacho, Lisa Gibson, Rebecca Umbach, Charlotte Heleniak, and Nim Tottenham. Adaptation in the face of adversity: Decrements and enhancements in children's cognitive control behavior following early caregiving instability. *Dev. Sci.*, 24(6):e13133, November 2021.

[30] Jason S Moser, Mark W Becker, and Tim P Moran. Enhanced attentional capture in trait anxiety. *Emotion*, 12(2):213, 2012.

[31] Ravit Hadar, Henriette Edemann-Callesen, Elizabeth Barroeta Hlusicka, Franziska Wieske, Martin Vogel, Lydia Günther, Barbara Vollmayr, Rainer Hellweg, Andreas Heinz, Alexander Garthe, and Christine Winter. Recurrent stress across life may improve cognitive performance in individual rats, suggesting the induction of resilience. *Transl. Psychiatry*, 9(185):1–9, August 2019.

[32] Xiangyu Kong, Fanyang Kong, Kailian Zheng, Min Tang, Yi Chen, Jiahuan Zhou, Yi Li, Le Diao, Shouxin Wu, P. Jiao, Tong Su, and Yu-Chao Dong. Effect of psychological–behavioral intervention on the depression and anxiety of covid-19 patients. *Frontiers in Psychiatry*, 11, 2020.

[33] Xiangyu Kong, Kailian Zheng, Min Tang, Fanyang Kong, Jiahuan Zhou, Le Diao, Shouxin Wu, P. Jiao, Tong Su, and Yu-Chao Dong. Prevalence and factors associated with depression and anxiety of hospitalized patients with covid-19. *medRxiv*, 2020.

[34] Ben Coleman, Elena Casiraghi, Hannah Blau, Lauren Chan, Melissa Haendel, Bryan Laraway, Tiffany J. Callahan, Rachel R. Deer, Ken Wilkins, Justin Reese, and Peter N. Robinson. Increased risk of psychiatric sequelae of COVID-19 is highest early in the clinical course. *medRxiv*, page 2021.11.30.21267071, December 2021.

[35] Ahmad A. Toubasi, Rand B. AbuAnzeh, Hind B. Abu Tawileh, Renad H. Aldebei, and Saif Aldeen S. Alryalat. A meta-analysis: The mortality and severity of COVID-19 among patients with mental disorders. *Psychiatry Res.*, 299:113856, May 2021.

[36] Marcel S. Woo, Jakob Malsy, Jana Pöttgen, Susan Seddiq Zai, Friederike Ufer, Alexandros Hadjilaou, Stefan Schmiedel, Marylyn M. Addo, Christian Gerloff, Christoph Heesen, Julian Schulze Zur Wiesch, and Manuel A. Friese. Frequent neurocognitive deficits after recovery from mild COVID-19. *Brain Commun.*, 2(2):fcaa205, July 2020.