



The Covid-19 pandemic had polarizing effects on trait scores depending on a person's resilience and predispositions: A longitudinal prospective study[☆]

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ABSTRACT

While Covid-19 is, first and foremost, a pernicious physical illness, its highly contagious nature has led to significant disruption in social life and psychological stress, occasionally resulting in dire mental health consequences that are still not fully understood. To address this issue, a prospective longitudinal design study was conducted by administering standard self-reporting questionnaires covering the NEO-five factor inventory (NEO-FFI), shyness, alexithymia, autism quotient, anxiety, depression, and sensory processing sensitivity (SPS). A total of 114 participants (of which 71.93% were females) with an average age of 30.29 (standard deviation = 11.04) completed the survey before and a few months after the pandemic. Results revealed the distribution of population scores to become more extreme in either positive or negative trait directions despite the stability of average trait scores across the population. Higher resilience was found to be positively correlated with improved trait scores post-pandemic but corona anxiety score was not correlated with trait score changes. In addition, in the subjects with moderate negative trait scores, agreeableness and autism scores and in subjects with high negative trait scores, openness, SPS and shyness scores were significantly correlated with trait scores changes post-pandemic. These results reveal the nuanced effects of the pandemic on the people's psychological well-being and highlight vulnerabilities for certain groups despite the overall stability of population that needs to be taken into account for mental health policies going forward.

1. Introduction

The spread of Covid-19 has caused unprecedented challenges for people worldwide, particularly due to the drastic degradation of social life and increased isolation. The pandemic has affected not only people's physical health but also had a significant impact on people's mental health due to chronic psychological stress [1–4]. These findings are in agreement with previous research showing that past experiences with outbreaks of severe respiratory diseases, such as SARS and MERS, have also consistently caused psychological

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consequences [5,6]. To prevent the spread of the virus, people were forced to practice social distancing and self-isolation, which are known to lead to frustration, stress, and depression [7]. Also, the risk of depression and anxiety was reported to increase with social isolation [8]. People who are put in quarantine are reported to have more mental health problems than others [9] with symptoms continuing even years after quarantine ends [10]. As the Covid-19 pandemic continues, it is predicted that we will face a long-term global mental health crisis [8,11–14]. In planning for and remedying the resulting mental consequences, it is imperative to have a detailed and quantitative understanding of the psychological impacts of the Covid-19 pandemic across a wide range of traits and mental dispositions.

Previous research has shown that Covid-19 has led to an increase in psychological stress and mental health problems, such as depression, anxiety [3,15–18], and post-traumatic stress disorder [19,20]. Additionally, research has highlighted the role of people's personality styles and dispositions in the context of Covid-19, including neuroticism, extraversion, openness, agreeableness, conscientiousness [21,22], alexithymia [23–25] and autistic characteristic [12,26,27]. A systematic review and meta-analysis found that the Covid-19 pandemic is associated with an increase in symptoms of depression, anxiety, and psychological distress, as well as a decrease in subjective well-being. The authors note that the pandemic has created a global mental health crisis, and that more research is needed to understand the long-term impacts on mental health [3].

Other research concluded that individuals experiencing elevated levels of alexithymia are more likely to have decreased levels of mental well-being during the Covid-19 pandemic [28]. It is observed the Covid-19 pandemic has had a unique impact on individuals with autism spectrum disorder (ASD) [29]. In addition, neuroticism was found to be linked to more negative impacts related to the Covid-19 pandemic [30]. These population may be particularly vulnerable to the negative psychological effects of the pandemic.

On the other hand agreeableness, and conscientiousness are found to had a positive correlation with guideline adherence for Covid-19 with contradictory results for extraversion [30,31]. Based on these findings, it is suggested that individual personality traits might significantly impact people's responses to the pandemic. The authors suggest that personality styles may play an important role in people's responses to the pandemic.

Despite the existing literature on the psychological impacts of Covid-19 on certain isolated traits or personality styles [32,33], little is known about the overall picture of the Covid pandemic by considering multiple personality styles and mental dispositions in the same population before and after the pandemic. In particular, considering a cohort of traits in a within-subject design is desirable for gaining a more accurate and comprehensive picture of the pandemic consequences and the possible heterogeneities in the affected population.

In this prospective longitudinal study we have examined the changes in a total of 11 traits and dispositions before and after the pandemic, to gain a deeper understanding of the long-term psychological consequences of Covid-19. This information can inform the development of targeted interventions to mitigate the mental health impacts of the pandemic.

2. Methods

2.1. Study design

Our study is an observational longitudinal panel study, with trait scores as the outcomes and the predictors being trait scores and the effect of COVID on scores.

Our studied population was representative of adults with a mean age of 30.29 (SD = 11.04) and was somewhat skewed toward females (71.93% female). Due to the fact that the questionnaires were administered online, most of our subjects consisted of educated urban people.

2.2. Subjects

875 individuals willingly participated in filling out questionnaires using a Google form that was available online in our previous work [34]. In the previous study, subjects were solely required to provide a valid email address, which was utilized to establish contact with them for this current study. Based on the self-reports submitted, it was found that 83 participants had physiological or psychological disorders. Out of these, 45 reported physiological disorders and 38 reported mental or brain-related issues. The group with brain or mental health issues was excluded. From remaining 837 subjects in our previous work from across Iran [34] (prior to January 2020, it should be noted that the pandemic almost started in February 2020 in Iran), 114 subjects (71.93% female) with a mean age of 30.29 (SD = 11.04) chose to participate in the study for the second time by filling out seven standard questionnaires which included the NEO-five factor inventory (NEO-FFI), shyness, alexithymia, autism quotient, anxiety, depression, and sensory processing sensitivity (SPS) covering a total of 11 traits a few months before and again a few months (within June to September 2020 Period) after the Covid pandemic (pre- and post-pandemic periods, respectively). These subjects also filled out mental resilience and Corona anxiety questionnaires to examine their possible roles in the mental health state in the post-pandemic period.

2.3. Questionnaires

The Persian version of seven questionnaires including Adult Autism Spectrum Quotient [35], Revised Cheek–Buss Shyness Scale [36], Toronto Alexithymia Scale [37], Beck Anxiety Inventory [38], Goldberg's Depression scale [39], NEO Five-Factor Inventory (neuroticism, openness, extraversion, conscientiousness, and agreeableness) [40] and Highly Sensitive Person Scale (sensory processing sensitivity) [41] are used and described in the previous work [34].

Mental Resilience questionnaire is a self-report measure with 25-item [42]. The response scale ranges from 0 to 5, from strongly disagree to strongly agree, respectively. The Alpha Cronbach of translated resilience questionnaire was 0.91 in this study.

Corona Disease Anxiety Scale (CDAS) questionnaire is an 18-item questionnaire to assess anxiety of people about Covid-19 [43]. This questionnaire scale ranged from 0 to 3 never to always, respectively. The Alpha Cronbach of Persian questionnaire was 0.91 in this study.

2.4. Data analysis

All data analyses were done by MATLAB 2017b. The scores for each question were z-scored across subjects before and during the Covid pandemic separately for hierarchical clustering. For other analyses, the scores for each questionnaire were converted to a percentage. Logistic regression was done using MATLAB mnrfit, with the outcome being positive or negative group membership and predictor being the resilience or Corona anxiety scores. It should be noted that we did not include members of the post moderate group in the logistic regression due to their small number. Hierarchical clustering and Alpha Cronbach calculation were done similarly to our previous work [34].

2.5. Statistical tests and power analysis

The significant p-value for all statistical analyses was 0.05. T-test was used for significant changes in the means (e.g. Fig. 1c and d, fig S1a-b). Pearson’s correlation coefficient was used for correlation analysis and significances. The Demming regression is used to draw the regression lines in scatter plots (e.g. Fig. 4b). Since in all these plots trait scores are regressed against each other and both y- and x-axis represent random variables using regular regression which assumes only y to be a random variable is not appropriate. Demming regression is one way to deal with situations where both y and x are random variables. For Demming regression, equations are adapted from the following references [44,45].

A power analysis was conducted to detect a 5% change in trait scores with standard deviation of 9%, as determined from our pilot population, with 80% power and a p-value of 0.05 [46] (<http://sample-size.net/correlation-sample-size/>), indicating that the minimum sample size required was 104, which is lower than our final sample size of 114.

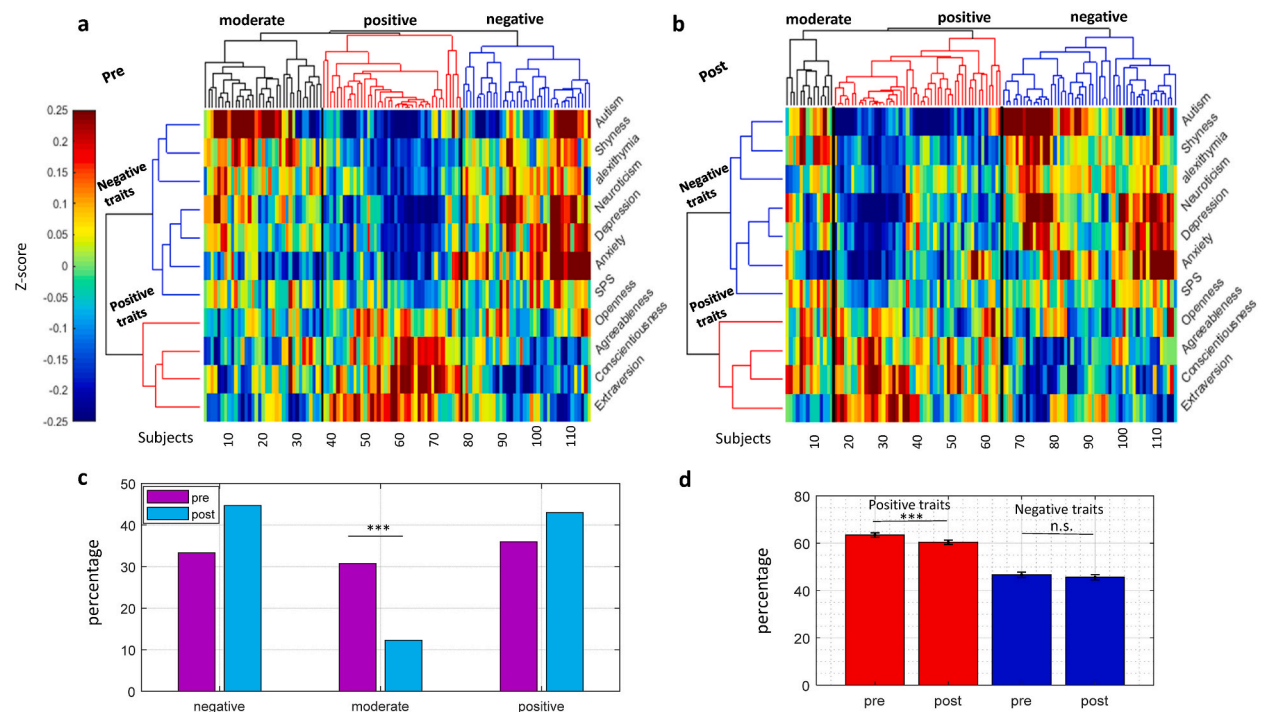


Fig. 1. Change of subject groups before and after Covid-19. Clustergram of subjects (columns) before Covid-19 (a) and after Covid-19 (b) color-coded by z-scores of 11 traits (rows) with rows and columns sorted by HC. c, Percent of subjects in the three subject groups before and after Covid-19. d, Average score of positive traits and negative traits clusters before Covid-19 ($t_{113} = 9.23$) and after Covid-19 ($t_{113} = 8.19$), $***p < 1e-3$. Pre = before Covid-19, post = after Covid-19. Error bars represent s.e.m. here and thereafter. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

3. Results

3.1. Changes before and after Covid-19

To address how the Covid-19 pandemic might have affected the individual personality styles and traits, we compared the subjects' scores ($n = 114$) to questionnaires spanning 11 traits before the pandemic's start and about four months after the pandemic (pre and post-Covid periods, respectively). Consistent with our previous report [34], the traits were grouped into two main clusters by unsupervised hierarchical clustering (HC). The first trait cluster which included openness, extraversion, conscientiousness, and agreeableness constituted the positive trait cluster. The second trait cluster, which included autism, shyness, alexithymia, anxiety, depression, neuroticism, and sensory processing sensitivity formed the negative trait cluster. Notably, both trait clusters were stably found in pre- and post-Covid periods (Fig. 1a and b).

Subjects also showed three main groups using HC in both pre and post-Covid periods. These groups included subjects with high scores in positive traits and low scores in negative traits (positive subject group), subjects with high scores in negative traits and low scores in positive traits (negative subject group), and subjects with moderate negative and positive scores (moderate group) (Fig S1a-b). Interestingly, we found a significant shrinkage in the number of moderate subjects in the post compared to the pre-Covid period (Fig. 1c). However, the subjects migrating out of the moderate group did not all transfer to the negative group as might be expected from the hardship inflicted by Covid. Notably, subjects migrating out of positive and negative groups mostly did not end up in the moderate group but moved to the opposite extreme (Table 1). This resulted in a concurrent increase in the percentages of subjects in both positive and negative groups. This concurrent increase in positive and negative groups somewhat canceled out each other such that the overall negative and positive population scores remained relatively stable in the post compared to the pre-Covid period (Fig. 1d). The overall score of negative traits did not show a significant change from pre-Covid to post-Covid era (see figure captions for stats throughout). The positive trait scores showed only a small (3.2%) but significant reduction (Fig. 1d). Thus, Covid-19 seems to have polarized participants into positive and negative groups while keeping the average positive and negative trait scores relatively stable across the population.

3.2. Effect of corona anxiety and resilience

To address the factors that might have caused the differential migration of subjects toward positive and negative traits during the pandemic, we administered two additional questionnaires in the post-Covid era for the subjects. One measured mental resilience [42, 47], and the other measured the degree of anxiety caused by the Covid pandemic (Corona anxiety, [43]). The resilience questionnaire consists of 25 questions and assesses the individual's innate ability to deal with stressful environmental conditions [47], while the Corona anxiety questionnaire consists of 18 questions and assesses the degree of anxiety caused by Covid-19 [43]. Across subjects, resilience and Corona anxiety showed a significant negative correlation ($r = -0.19$, p -value = 0.04 Fig S1c). This suggests that subjects with higher resilience tended to experience less Corona anxiety, and vice versa (without implying the causative direction). Furthermore, the results showed that, if added to the previous 11 traits, resilience itself falls within the positive traits, while Corona anxiety falls within the negative traits (Fig S1d).

We hypothesized that the subjects with higher resilience fared better during the pandemic and migrated to the positive group. In comparison, the subjects with lower resilience were more frequently found in the negative group. Indeed, the resilience score had a trending correlation with the rise in subjects' scores for positive traits from the pre-to the post-Covid period (Pearson's $r = 0.16$, p -value = 0.07) and negatively correlated with the rise in subjects' scores for negative traits (Pearson's $r = -0.20$, p -value = 0.02) (Fig. 2a-b). Consistently, further analysis showed that the subjects in the highest resilience quartile became almost exclusively concentrated in the positive group in the post-Covid era (93% post vs 75.2% pre in the positive group). The opposite trend was observed in the lowest resilience quartile where the subjects became heavily biased toward the negative group in the post-Covid era (82.9% post vs 41.4% pre in the negative group) (Fig. 2c). Interestingly, no significant correlation was found between Corona anxiety and change of positive/negative trait scores were observed suggesting that anxiety about Covid-19 by itself was not a key determinant of how subjects fared during the pandemic (Fig. 2d-f). Additional analysis using logistic regression was performed to see which one of the Corona anxiety or resilience had better predictive power for the change of the subject groups. Consistently, results showed that resilience had a much larger effect on the change of the subject groups from pre to the post-covid era (coefficient of resilience and Corona anxiety are 0.24 (p -value = $1e-6$) and -0.04 (p -value = 0.03), respectively).

We repeated the correlations between resilience and post minus pre scores separately for positive, moderate, and negative subject groups in the pre-Covid era. Results showed that the resilience score was positively correlated with the increase of subjects' scores for

Table 1

Confusion matrix changes in the three subject groups before and after Covid-19. Confusion matrix showing the percentage of subjects in positive, moderate, and negative groups before (rows) and after (columns) the Covid-19 pandemic. The percentages are color coded and sum up to 100.

pre/post (%)	positive	moderate	negative	Pre percent
positive	27.19	2.63	6.14	35.96
moderate	7.01	8.78	14.92	30.71
negative	8.78	0.87	23.68	33.33
Post percent	42.98	12.28	44.74	100

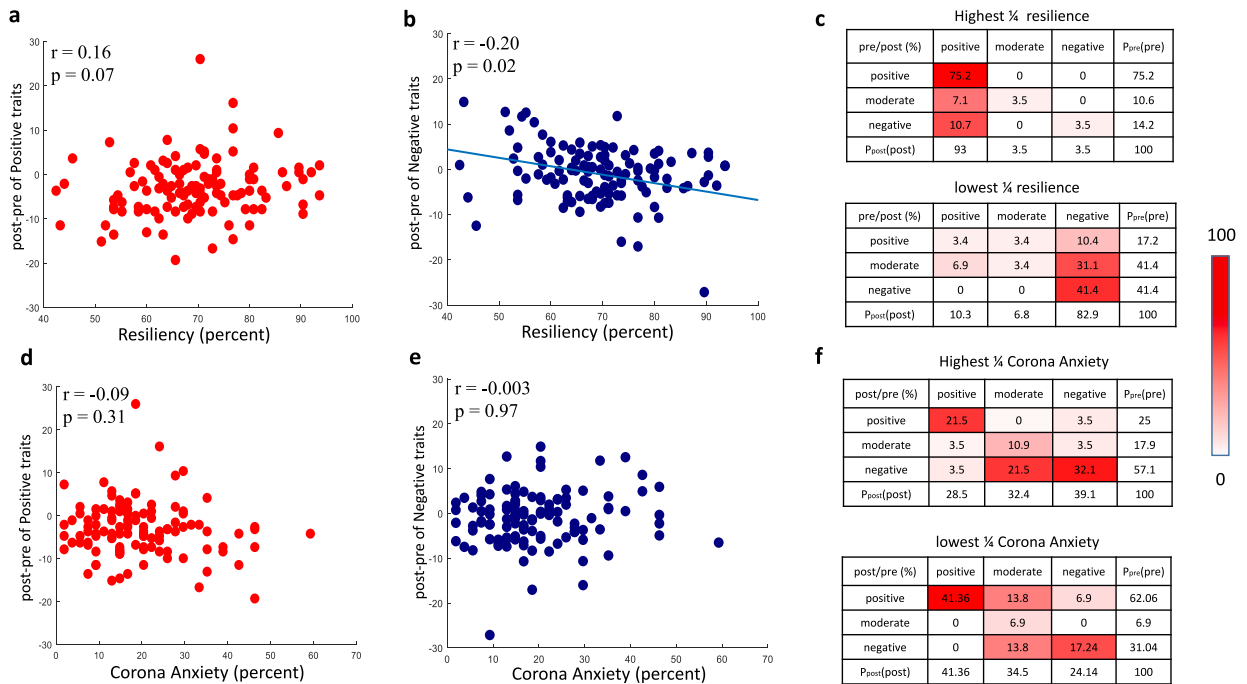


Fig. 2. Change of post minus pre trait scores as a function of resiliency and Corona anxiety. a, Scatter plot of positive traits score change as function of resiliency across subjects. b, Same as a but for negative trait score change. c, Confusion matrices showing the percent of subjects in positive, moderate, and negative groups before (rows) and after Covid-19 (columns) in subjects with highest resiliency quartile, scores = 76.8–93.6%, $N = 28$, and lowest resiliency quartile, scores = 42.4–62.4%, $N = 29$, respectively. d-e, Same format as a-b but for Corona anxiety for positive trait score change and negative trait score change. f, Same format as c but for highest Corona anxiety quartile, scores = 25.9–85.18%, $N = 28$, and lowest Corona anxiety quartile, scores = 1.8–12.9%, $N = 29$. The best Deming regression line in the scatter plots is derived using the Deming method and it is shown only in the scatters where its p-value was significant in this figure and hereafter.

positive traits and negatively correlated with the increase of subjects' scores for negative traits going from the pre to post-Covid period in all three subject groups (Fig. 3a–b). Once again, Corona anxiety did not show a significant correlation with changes in trait score within any of the three subject groups, consistent with a lack of an effect across all subjects (Fig S2a-b).

3.3. Effect of predispositions

To investigate whether the subjects' trait predispositions also played a role in the trait scores in the post-Covid era, the correlation between pre-Covid positive and negative trait scores with post minus pre scores was examined. For subjects in the negative or positive groups in the pre-Covid era, the results showed almost no correlation between overall pre-Covid positive and negative trait scores and the change in the trait scores (Fig. 4a,c). However, for the subjects in the moderate group in the pre-Covid era, we found a significant negative correlation between the positive trait scores and the post minus pre-positive trait scores ($r = -0.48$, p-value = 0.003) (Fig. 4b). This means that in the moderate group, the subjects with a higher positive trait score in the pre-Covid era ended up with a larger reduction of their positive trait score in the post-Covid era. Additional analysis done separately for individual positive trait scores showed a significant negative correlation for agreeableness score ($r = -0.36$, p-value = 0.03) (Fig S3a) and a negative trend for openness ($r = -0.24$, p-value = 0.16), extraversion ($r = -0.15$, p-value = 0.37) and conscientiousness ($r = -0.26$, p-value = 0.12). These findings suggest that individuals with higher positive scores, in particular, agreeableness tend to be more adversely affected by the pandemic. There was not a significant correlation between pre-Covid negative scores, and positive trait score change in the moderate group ($r = 0.11$, p-value = 0.52); looking at individual negative trait scores showed a borderline positive correlation between autism and improvement in the post minus pre-positive trait scores ($r = 0.32$, p-value = 0.05, Fig S3b).

While there was no significant correlation between the overall pre-Covid scores in the negative group, some individual traits showed a significant correlation. There was a significant reduction of the post minus pre-negative scores for individuals with higher openness ($r = -0.43$, p-value = 0.006) and for individuals with higher SPS scores ($r = -0.37$, p-value = 0.02) (Fig S4a-b). There was also a borderline trend for a decrease of the post minus pre-positive scores for individuals with higher shyness scores ($r = -0.31$, p-value = 0.05) (Fig S4c). We found no effect of individual traits in individuals in the positive group ($-0.28 < r < 0.16$, p-value > 0.07). However, we note if the p-values reported for individual traits are to be corrected using the most conservative family wise correction (e.g., Bonferroni), none of the individual trait effects remain significant. Nevertheless, the negative correlation between the positive trait scores and the post minus pre-positive trait scores remains significant even with Bonferroni correction (12 comparisons, corrected

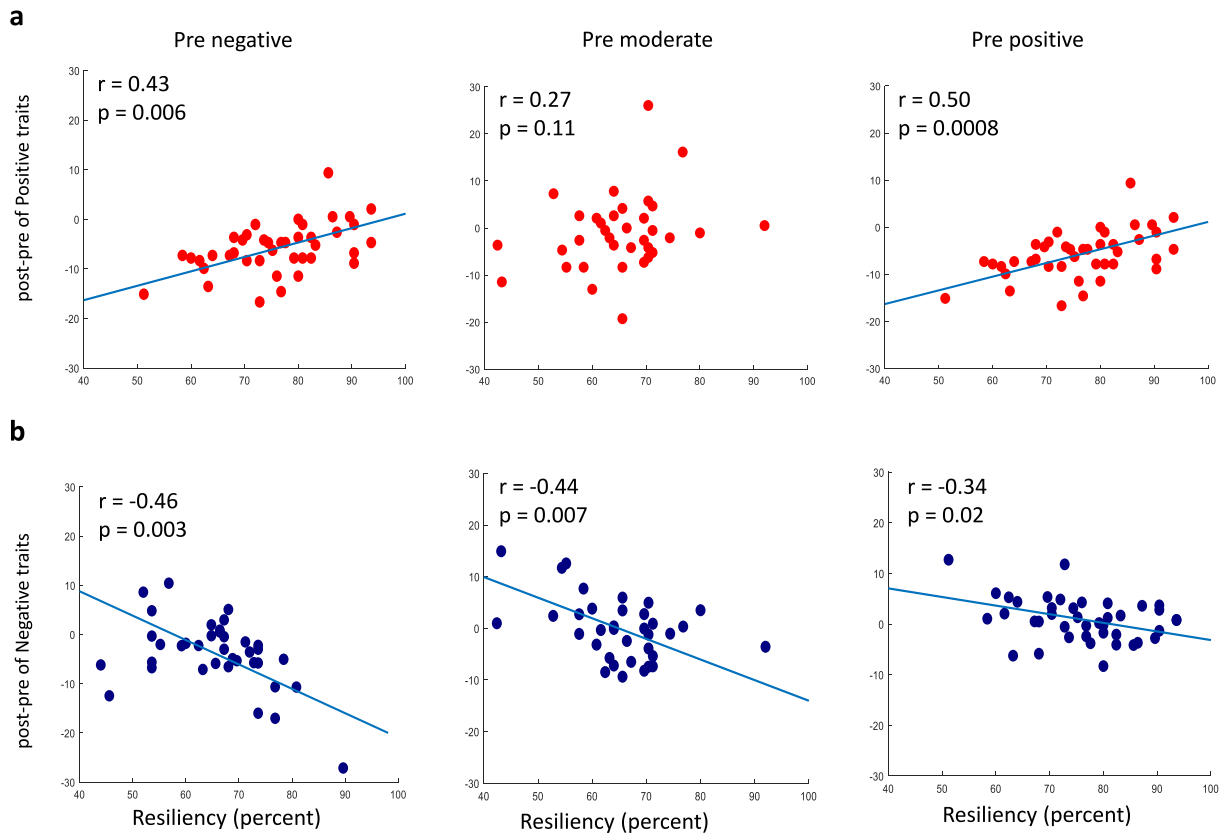


Fig. 3. Correlation between resilience and trait score change. a, Scatter plot of positive trait score change and resilience separately in the three subjects groups. b, Same as a but for negative trait score change.

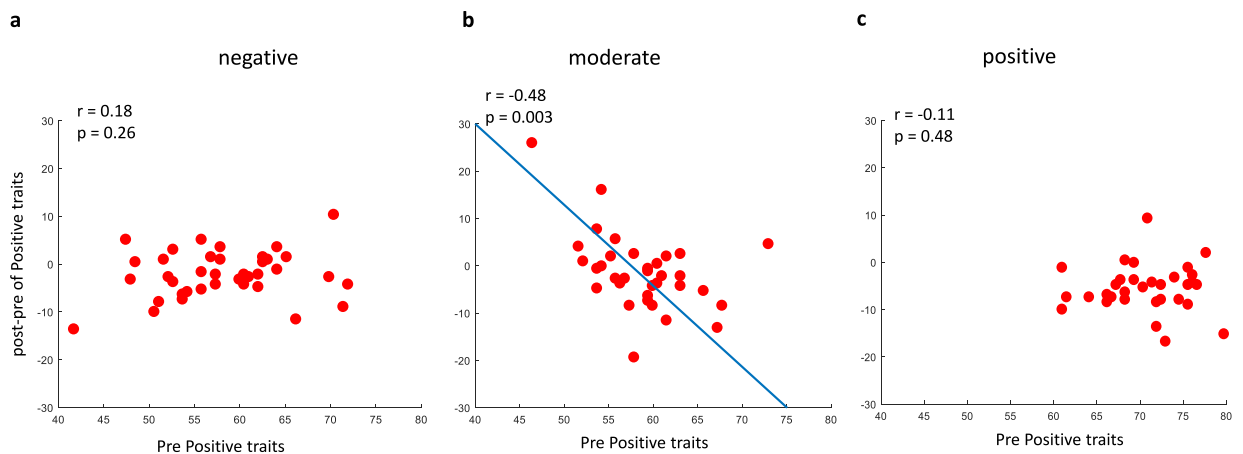


Fig. 4. Correlation of positive trait score change and positive traits separately in a, negative b, moderate and c, positive subject groups in the pre period.

p-value = 0.036, Fig S5).

4. Discussion

Here, we report the results of a longitudinal study that tracked changes in 11 trait scores for subjects before and a few months into the Covid pandemic. The traits considered were classified as positive (openness, extraversion, conscientiousness, and agreeableness) and negative (autism, shyness, alexithymia, anxiety, depression, neuroticism, and sensory processing sensitivity) groups using

unsupervised learning [34]. Surprisingly, results showed that while Covid-19 significantly reduced the overall scores for positive traits, the effect was relatively small, and there was no significant change in the overall negative scores (Fig. 1d). Instead, we found migration of subjects, and particularly those with moderate scores to groups with more extreme positive and negative trait scores. We found two underlying factors correlated with the fate of subjects in the post-Covid era. First, higher resilience [42] generally resulted in increased positive trait scores and decreased negative trait scores across the population (Fig. 2). Unlike resilience, we did not find any significant effect of the degree of Corona anxiety. The second factor that specifically affected subjects with moderate trait scores was their positive predispositions in the pre-Covid era such that higher positive scores in this group predicted a larger reduction of positive trait scores in the post-Covid era (Fig. 4).

While the outbreak of the Covid-19 pandemic has certainly harmed the mental health of individuals, these effects have been relatively short-lived as people learned to adjust to the new social norms. In fact, reports show that as early as mid-2020, mental health conditions became almost comparable to the pre Covid period [32,48]. In this regard, our post-Covid scores were collected about four months following the outbreak of the Covid-19, and they showed relatively small changes in overall positive and negative trait scores, confirming previous findings. Despite this apparent stability in the overall scores, our results showed that Covid pandemic created a more bimodal distribution toward positive and negative groups and reduced the number of subjects in the moderate score group (Fig. 1c). We found that resilience scores had a significant impact on how individuals responded to the pandemic. This confirms, the important role that resilience played in the Covid pandemic, which is in line with previous research [49–52].

We should mention that trait scores are usually stable, as confirmed by the high alpha Cronbach of each questionnaire in our previous work [34]. Despite this, there is evidence that the individuals' traits or disorder scores, such as schizophrenia [53], depression, anxiety, or obsessive-compulsive disorders [54] or even personality styles [33], may change in stressful situations and in the Covid pandemic.

Interestingly, moderate subjects with higher agreeableness tended to have lower positive trait scores in the post-Covid era, suggesting that social isolation might have had a more detrimental effect on highly agreeable people (Fig S3a). This finding is consistent with previous research that showed individuals with low agreeableness to be better equipped to adjust psychologically to problems imposed by Covid [52]. The positive correlation between the individuals' autism score and the improvement in positive trait scores in the post-Covid era is also interesting (Fig S3b). Indeed while the impact of Covid-19 is reported to be more severe for people with specific pre-existing mental problems [55–58], some improvements are also observed in people with attention deficit hyperactivity disorder (ADHD), bipolar disorder, and autism [59–63]. One possibility is that social isolation during the pandemic era might have helped individuals with higher autism scores [62,63]. This result emphasizes the importance of the big five personality styles in such phenomena [22,64]. In contrast to the general effects of resilience, these effects were mostly observed in subjects in the moderate group in the pre-Covid period. It is important to recognize that while there have been some advancements in treating individuals with previous mental health issues who contract Covid-19, the virus itself may put patients who already have mental health concerns, such as schizophrenia, at greater risk for more severe symptoms or even death [65]. Additionally, those who survive Covid-19 may experience ongoing psychological effects like PTSD, anxiety, and depression that can lower their overall quality of life [66].

In individuals in the negative group, higher openness scores resulted in lower negative scores post-Covid, while higher shyness scores resulted in lower positive scores (Fig S4). These results are consistent with previous literature indicating that openness predicts lower perceived stress and is positively associated with subjective well-being [52], whereas shyness is associated with negative feelings and makes shy people more vulnerable to psychopathology due to a lack of social interaction [67,68]. What seems novel here is that these two traits predominantly exert their influence in the negative group, not the moderate or positive groups. Also, higher SPS had a positive effect in this group and was correlated with lower negative scores post-Covid. This is consistent with a previous finding that showed SPS is not necessarily a vulnerability factor in the covid pandemic [69].

To acknowledge some constraints, it's worth noting that our study's data originated solely from Iran using online questionnaires, so additional research is required in order to make more general conclusions. Additionally, despite being longitudinal, the findings are correlational and observational in nature.

5. Conclusion

In summary, our results provide evidence that in our sample, participants were polarized toward positive and negative groups with a heterogeneous response across the population depending on their resilience and certain predisposition in the few months following Covid-19. These individual score changes happened despite the overall stability of the average positive and negative groups across the population. In particular, the migration of the moderate subject group to more negative and positive traits, as well as its reliance on autism and agreeability scores, appears particularly noteworthy. This implies that more social individuals may have felt the negative impacts of the pandemic and the subsequent social isolation more acutely. Note that this research tracked individuals for a few months after the covid outbreak, and further investigations are still needed as the pandemic continues to spread globally. These findings may provide important clues for mental health policies to detect and support with vulnerable groups in the post-Covid era.

Availability of data and material

All data needed to evaluate the conclusions in the paper are present in the paper and/or the Supplementary Materials. Data and code can be made available at reasonable request.

Author contribution statement

Taraneh Attary: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Leila Noorbala: Conceived and designed the experiments; Performed the experiments; Wrote the paper.

Ali Ghazizadeh: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of competing interest

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

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Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.heliyon.2023.e18399>.

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