

The Inflexible Mind: A Critical Factor in Understanding and Addressing COVID-19 Vaccine Hesitancy

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Abstract

Background

Vaccine hesitancy has gained heightened relevance amid the COVID-19 pandemic, underscoring the urgency of understanding its determinants. This study explores the association between Covid-19 vaccine hesitancy, mental health variables and inflexible thinking.

Methods

A convenience sample of 252 UK adults was assessed online between June 2021 – July 2022 (when Covid-19 lockdown restrictions had finally eased). We assessed participants using the Oxford Covid Vaccine Hesitancy Scale (OCVHS), various aspects of mental health, using: the Obsessive-Compulsive Inventory-Revised (OCI-R), Compulsive Personality Assessment Scale (CPAS), Depression, Anxiety, and Stress scale (DASS-21), and finally, performance on a computerized version of the Wisconsin Card Sort Task (WCST). This study was preregistered at the Open Science Framework (<https://osf.io/xd5wz>).

Results

Multiple regression analyses showed that only cognitive inflexibility, and specifically the WCST item of perseverative errors, significantly predicted vaccine hesitancy.

Conclusion

Our exploratory analysis provides the first evidence that cognitive inflexibility, measured using an objective task, is an independent risk-factor for vaccine hesitancy. Public health strategies should consider the impact of an inflexible thinking style on the decision-making of those most at risk of vaccine hesitancy and adapt interventions accordingly.

Keywords: pandemic, covid, cognitive rigidity, cognitive flexibility, perseveration.

1 **Introduction**

2 The successful introduction of vaccination against Covid-19 needs to be set against the
3 backdrop of a substantial minority of the population who declined vaccination. Understanding
4 the factors influencing vaccine attitudes and intentions therefore represents an important plank
5 in the armoury against COVID-19 and any future pandemics (Wang & Zhang, 2021). The
6 seminal paper by Freeman et al. (2020), which investigated over 5000 members of the UK
7 public, using the Oxford Covid-19 Vaccine Hesitancy Scale (OCVHS), found 596 (11.7%)
8 participants considered to be vaccine hesitant.

9
10 Various socio-demographic determinants relating to vaccine hesitancy, broadly defined,
11 including hesitancy among parents to vaccinate their children, have been identified (reviewed
12 in Hudson & Monelpare, 2021, Pires et al., 2022). These include young age, female gender,
13 poor socio-economic status, low educational achievement, poor health literacy, rural living,
14 and parental status (the more children in a family, the higher parental hesitancy). Other,
15 potentially modifiable factors, such as mistrust in authority, disgust sensitivity, and risk
16 aversion were also associated with hesitancy. However, the studies in this field have shown
17 considerable variability and inconsistency. As Pires and colleagues (2022) noted, demographic
18 variables may be particularly inconsistent because they vary according to the social, political
19 and/or cultural characteristics of a country. In this context, it is important to assess variables
20 that are less likely to vary according to cultural factors, including for example, cognitive styles
21 and/or traits.

22
23 Medical misinformation and lack of trust in civic authorities influence vaccine hesitancy
24 (Honora et al., 2022), and in some cases, may be considered an extremist or radical attitude,
25 close to some forms of political polarization (Shapiro et al., 2016). Inflexible thinking styles

1 are reported to underpin extreme political partisanship (Zmigrod et al., 2020) and may thus be
2 expected to influence vaccine hesitancy as well. Few studies have investigated inflexible
3 thinking, or cognitive function defined more broadly, in relation to vaccine hesitancy. One
4 such study (Acar-Burkay & Cristian, 2022) identified a relationship between vaccine hesitancy
5 (Freeman et al., 2020 and Garry et al., 2020) and executive function, evaluated using a Stroop
6 task and the Montreal Imaging Stress Task. Another study (Cao & Li 2022) identified a
7 relationship between vaccine hesitancy measured on a two-item version of the Covid-19
8 Vaccine Intention Scale (Huynh & Senger, 2021) with self-control evaluated also on a Stroop
9 task. A third study (Mazzuca et al., 2021) found evidence suggesting a relationship between
10 vaccine hesitancy and flexible adaptation to new concepts, while a fourth (Wang & Zhang,
11 2021) found that psychological flexibility and a positive coping-style in parents were linked
12 with reduced Covid-19 vaccine-hesitancy among the offspring (Wang & Zhang, 2021; Tan et
13 al., 2022).

14

15 Mainly investigated within clinical populations, such as patients with obsessive
16 compulsive spectrum disorders (Fineberg 2018, Chamberlain et al., 2021), cognitive
17 inflexibility is a multifaceted concept (Robbins et al., 2019) that may be generally described
18 as the incapacity to flexibly adjust one's behavior in response to changing circumstances,
19 update one's knowledge, and maintain optimum decision-making (Chamberlain et al., 2021;
20 Grant and Chamberlain, 2023). The impact of cognitive inflexibility on psychosocial
21 functioning includes difficulty adaptively changing behaviours in response to changing
22 environmental contingencies or the likelihood of reward or punishment. Moreover, conditions
23 of threat and uncertainty amplify cognitive rigidity. Therefore, in this paper, we decided to
24 focus on the neurocognitive measure of cognitive inflexibility, that, in our a-priori hypothesis,

1 might be expected to lead to increased resistance toward the introduction of new
2 vaccination policies and reluctance to accept vaccination.

3
4 Cognitive inflexibility is usually found as stable trait unrelated to illness severity (Clarke
5 et al., 2023) and is a known risk factor for the development of obsessive-compulsive disorder
6 (OCD), a disorder characterised by the occurrence of repetitive thoughts and/or behaviours
7 that persist despite being functionally impairing (Albert et al., 2019b; Benatti et al., 2021;
8 Pellegrini et al., 2022). Increased rates of inflexibility are seen not only in those with OCD but
9 also in their asymptomatic first-degree relatives (Chamberlain et al., 2007). Inflexible thinking
10 is additionally included as a core trait in the DSM-5 definition of obsessive-compulsive
11 personality disorder (OCPD: DSM-5), a disorder involving rigid adherence to rules,
12 undermining efficiency. Increased rates of cognitive inflexibility have been reported in a non-
13 clinical sample of students with OCPD (Fineberg et al., 2015). Cognitive inflexibility is also
14 present in other disorders characterized by preservative behaviours such as addictive disorders,
15 that increased during the pandemic phase (Martinotti et al., 2020).

16
17 Accurate assessment of cognitive inflexibility is likely to require the use of objective
18 measures as prior work suggests that individuals are particularly poor at recognizing this trait
19 in themselves, possibly because of coexisting metacognitive problems (Fineberg et al., 2021;
20 Rollwage et al., 2018). Objective tasks hold several advantages over clinical measures as they
21 are potentially less subject to rater-related error and may provide a window on the
22 underpinning neuropsychological mechanisms. One of the most commonly used and validated
23 paradigms is the Wisconsin Card Sorting Task (WCST, *Berg 1948; Grant & Berg 1948*),
24 which tests aspects of attentional inflexibility and behavioural perseveration (Clarke et al.,
25 2023 *in submission*). The WCST is the most abundant and extensively validated task within a

variety of cohorts for the assessment of cognitive inflexibility (Henry, 2006; Chamberlain et al, 2021).

Perseverative responses refer to persistent responses made by a participant based on a previously incorrect match despite feedback indicating the response is incorrect (Heaton et al., 1993) and is viewed as a key indicator of cognitive inflexibility (Miles et al 2021). Perseverative error as measured on the WCST quantifies the perseverative behaviour that occurs when a participant maintains the same response strategy after a rule change. Considered a failure to inhibit a previously learnt ‘prepotent’ response, perseverative errors have been the most widely used measure of cognitive inflexibility in studies of OCD and autism (Rosa-Alcázar Á et al., 2020; Landry et al., 2021).

Considering the pivotal role of inflexibility in disorders such as OCD and OCPD, self-rated scales of compulsive forms of behaviour such as the Obsessive-Compulsive Inventory-Revised (OCI-R: Foa et al., 2002), or the Compulsive Personality Assessment Scale (CPAS: Fineberg et al., 2015), measuring obsessive compulsive symptoms and traits, respectively, can be considered additional proxy clinical measures of aspects of cognitive inflexibility.

Aim

This exploratory analysis aimed to identify factors that could increase the risk of Covid-19 vaccine hesitancy among members of the public, with specific attention to cognitive inflexibility. To our knowledge, this is the first study investigating the relationship between Covid-19 vaccine hesitancy and cognitive inflexibility (as measured using an objective digital cognitive task: WCST) in a large population-based sample of adults. Knowing about cognitive inflexibility could be helpful for public health professionals, GPs and health care workers to better understand the factors determining resistance to vaccine acceptance and protesting

attitudes present in this sub-group of the population and adapt educational campaigns accordingly. Our findings might provide useful information for possible future pandemics and the need for new vaccines and/or be possibly generalized to vaccine hesitancy *per se* or indeed, vaccine hesitancy for other specific vaccines (e.g., influenza vaccine).

Methods

This study investigated vaccine hesitancy as a sub-project within a larger study investigating multiple aspects of pandemic-related psychosocial adjustment preregistered at the Open Science Framework (<https://osf.io/xd5wz>). Ethics was approved by the University of Hertfordshire Health and Human Science Ethics Committee with Delegated Authority (ECDA) (LMS/PGR/UH/04554) (Approval date: 21/5/2021). The study was conducted and reported according to the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) guideline (Eysenbach 2004).

Survey

Data collection began on 21st June 2021, when lockdown restrictions had eased, and concluded in July 2022. A cross-sectional survey was administered online using the secure web-based platform Gorilla Experiment Builder (Anwyl-Irvine et al., 2020; www.gorilla.sc). We used various approaches to enable recruitment from communities with diverse ethnic minorities, as well as students and health care workers, as these groups have been considerably disadvantaged by the pandemic (Meichun Mohler-Kuo et al., 2021). The survey was additionally promoted through social media platforms including: LinkedIn, Twitter, and Facebook, with a link that directed volunteers to the survey. UK citizens older than 18 years old could take part in the study.

Participants were first provided with an information sheet outlining the focus of the study. Those giving consent to participate were then asked to provide sociodemographic details including age (within a 10 year range), gender, ethnicity, level of education, occupation, living status. Following this, participants completed the OCVHS, the WCST, to objectively measure cognitive inflexibility and a selection of self-rated questionnaires evaluating aspects of mental health status related to inflexible thinking including obsessive-compulsive symptoms; obsessive-compulsive personality traits, depression, anxiety, and stress.

1. The Wisconsin Card Sorting Test (WCST: Berg 1948; Grant & Berg 1948)

An online version of the Wisconsin Card Sorting Test was used as an objective measure of participants' cognitive flexibility (the neurocognitive measure of interest for the analyses, according to our a-priori hypothesis). Participants are asked to match a target card to one of four stimulus cards presented in the upper portion of the screen, without being informed of the rules for matching the cards (i.e., number, colour, or shape) or of how often these rules would change. Instead, participants are forced to determine the rule based on feedback received on the previous attempt. Feedback is provided by means of a green 'thumbs up' symbol for correct responses, and a grey 'thumbs down' symbol for incorrect responses, presented in the lower right corner of the screen for 700ms. Participants complete 64 trials, with trials randomised within blocks for each participant. This version of the WCST takes approximately 7 minutes for a healthy individual to complete.

The WCST has four key metrics (perseverative errors, failure to maintain set, non-perseverative errors and total errors). The crucial metric of the WCST is the perseverative errors mean score, representing the most specific item for capturing attentional set-shifting problems and cognitive inflexibility (Bechara, Tranel, and Damasio, 2000; Verbruggen, Chambers, and Logan, 2013; Coulacoglou and Saklofske, 2017; Chamberlain et al, 2021).

Failure to maintain set occurs whenever an incorrect response follows a consecutive series of correct matches and when a participant alters his or her response strategies despite the rule remaining unchanged (this category of error is considered attentional). Non-perseverative errors (included in the item Total Errors) represent incorrect responses that do not match the perseverated-to principle and are usually regarded as arbitrary.

2. Oxford Covid-19 Vaccine Hesitancy Scale (OCVHS Freeman et al., 2020).

The OCVHS is a well-established measure of COVID-19 vaccine hesitancy (Freeman et al. 2020). It consists of 7 item-specific options, coded from 1 to 5, with higher scores indicating a higher level of vaccine hesitancy, giving a maximum total hesitancy score of 35, with “don’t know” being excluded from the scoring. In the seminal study by Freeman et al (2020), a mean OVHS score of 13.6 (SD: 7.3) was found in an adequately sized UK population sample. Individuals scoring four or more of the seven items (i.e. over half) with a clear vaccine hesitancy response (a rating of 4 or 5) is considered hesitant toward vaccination (Cronbach $\alpha = 0.94$).

3. Obsessive-Compulsive Inventory-Revised (OCI-R: Foa et al., 2002)

The OCI-R is an 18-item scale used to assess the severity of a range of common obsessive-compulsive symptoms and has a cut-off score of 21 to indicate a likely presence of obsessive-compulsive disorder (Foa et al., 2022). The scale has good internal consistency ($\alpha=0.93$).

4. Compulsive Personality Assessment Scale (CPAS: Fineberg et al., 2015).

The CPAS includes 8 items mapping onto each of the DSM-5 obsessive-compulsive personality disorder traits, the severity of which is evaluated using a 5-point Likert scale: 0 = absent; 1 = mild; 2 = moderate; 3 = severe; 4 = very severe. The CPAS has been validated

against an objective neurocognitive task measuring cognitive inflexibility (Fineberg et al., 2015) and therefore is a good self-rated tool to measure this endophenotype (Cronbach $\alpha = 0.86$).

5. *Depression, Anxiety, and Stress scale (DASS-21: Lovibond et al., 1995)*

The DASS-21 is frequently used in population-based studies (Henry & Crawford, 2011) for the self-assessment of the severity of anxiety (7 items), stress (7 items), and depressive (7 items) symptoms, which are rated on a 4-point likert scale: *0 Did not apply to me at all, 1 Applied to me to some degree, or some of the time, 2 Applied to me to a considerable degree, or a good part of time, 3 Applied to me very much, or most of the time*. The scale had good reliability ($\alpha = 0.95$).

Analysis

We used multivariate regression analyses, with OCVHS scores as the key outcome of interest, to assess potential predictors. We ran five regression models (as many as the different scores on the individual items of the WCST) and included for each model: the score on a specific item of the WCST; clinical self-rated questionnaires measuring obsessive-compulsive symptoms and traits and depressive/anxious/stress symptoms; and sociodemographic factors (age, gender, education, ethnicity, occupation, living status).

Results

We recruited 343 participants, and 252 completed the WCST and all questionnaires – revealing a completion rate of 66%. The majority ($N = 152$, 60%) fell in the age range 18-27 years, 70% of the sample were female; 150 participants (60%) defined themselves as having white ethnicity, 23.4% Asian, 4.7% African and 7.14% mixed. Most of the sample were

students (50%), and either living with parents (33%) or renting (27%) (see Table 1 of the supplementary materials). N=34 participants (13.5%) endorsed four or more of the seven items of the OCVHS with a hesitant response (a rating of 4 or 5) and could be considered hesitant toward vaccination (this percentage is in line with the one found by Freeman and colleagues in their seminal paper (11.7%). Scores on the self-rated questionnaires are shown in Table 1 and scores on the different WCST individual items are shown in table 2.

Table 1. Scores on self-rated questionnaires (N = 252).

	Mean	SD
Oxford Covid-19 Vaccine Hesitancy Scale (OCVHS)	13.37	7.17
Obsessive-Compulsive Inventory-Revised (OCI-R)	20.69	12.67
Compulsive Personality Assessment Scale (CPAS)	11.11	6.42
Depression, Anxiety, and Stress scale (DASS-21)	22.00	14.23

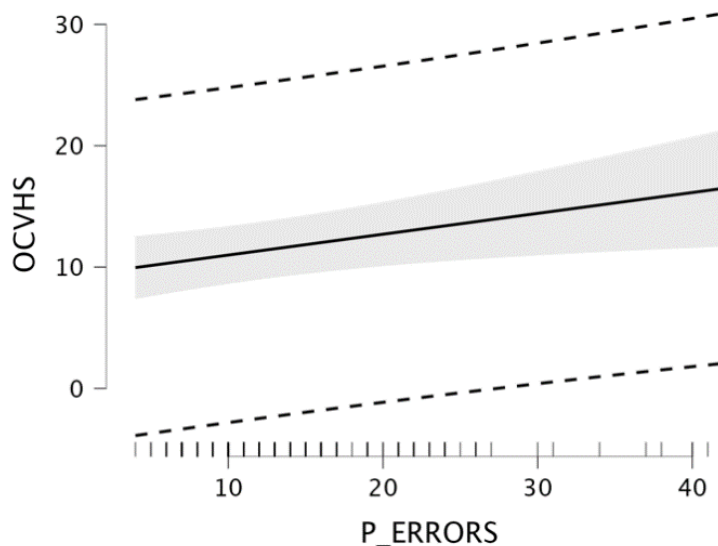
Table 2. Mean and standard deviation (SD) on the different WCST metrics (N=252).

	Correct responses	Perseverative errors	Failure to maintain set	Non-perseverative errors	Total errors
Mean	38.58	13.40	2.98	9.19	25.26
SD	9.57	6.60	2.58	4.88	9.48

We conducted multiple regression analyses for OCVHS as a dimensional outcome considering the following predictors: perseveration on the WCST; scores on clinical questionnaires measuring obsessive-compulsive symptoms and traits (OCI-R and CPAS) and depressive/anxious/stress symptoms (DASS-21); sociodemographic factors that could have an impact on vaccine hesitancy (age, gender, education, ethnicity, occupation, living status).

Only perseverative errors were a significant ($t = 2.15$, $p = 0.03$) predictor of vaccine hesitancy as assessed by the OCVHS (see figure 1 and table 3; table 2 of the supplementary materials). The model was significant ($F = 2.42$, $p = <0.001$), with an $R^2 = 0.22$. We found no evidence of multicollinearity with all VIF values <2 and tolerance being acceptable. None of the other individual items assessed by the WCST were significantly associated with vaccine hesitancy (see Table 3).

Figure 1. Regression-Plot of Oxford Covid Vaccine Hesitancy (OCVHS) scores and Wisconsin Card Sort Test Perseverative Errors



Note:
P_ERRORS – WCST perseverative errors; Grey area shows 95% confidence intervals; Dotted lines indicate 95% prediction intervals

Table 3. The predictive values for each WCST metric included in the regression model.

WCST Item	Unstandardized	SE	Standardized	t	p
Correct	-0.08	0.05	-0.10	-1.55	0.12
Failure to maintain set	0.11	0.17	0.04	0.65	0.51
Non-perseverative Errors	0.03	0.09	0.02	0.37	0.71
Total Errors	0.08	0.05	0.11	1.75	0.08
Perseverative errors	0.17	0.07	0.16	2.15	0.03

Discussion

As far we are aware, this is the first study to specifically focus on the association between objectively measured cognitive rigidity and vaccine hesitancy. Our analyses are exploratory in nature and show that cognitive inflexibility, particularly attentional set-shifting problems, is a significant predictor of vaccine hesitancy in the adult population. We consider the implications of these findings within the broader context of vaccine hesitancy, the impact of the COVID-19 pandemic specifically, and the potential role of cognitive inflexibility in shaping public attitudes toward vaccination.

Cognitive inflexibility, as assessed through a computerized version of the WCST, and in particular perseverative errors (the best item at capturing attentional set shifting problems), proved to be a significant predictor of vaccine hesitancy in a large adult population sample. Crucially, the relationship between cognitive rigidity, and in particular attentional set-shifting problems, and vaccine hesitancy persisted irrespective of the presence of self-rated obsessive-compulsive symptoms and traits, self-rated depressive/anxious/stress symptoms, age, gender,

1 level of education, ethnic group, occupation and living status. In our model, therefore, vaccine
2 hesitancy did not depend on sociodemographic factors or mental health problems.

3
4 Cognitive inflexibility is believed to be an enduring trait, at least in clinical samples
5 (Chamberlain et al., 2017), and according to our findings may serve as a cognitive mechanism
6 influencing reluctance towards vaccine acceptance. Vaccine hesitancy is undoubtedly
7 complex and multifaceted, and the unique circumstances surrounding the COVID-19
8 pandemic including heightened uncertainty, limited access to in-person medical consultations,
9 and the surge in health information via social media collectively, may have amplified the
10 challenges of addressing vaccine hesitancy. In particular, use of the internet and seeking
11 information via social media, activities that increased significantly during the pandemic, could
12 have caused an “infodemia” and amplified the uncertainty, therefore reinforcing cognitive
13 rigidity (Burkauskas et al., 2022). Amid the conditions of heightened risk and uncertainty,
14 individuals exhibiting cognitive inflexibility may have encountered particular challenges in
15 navigating this evolving information landscape, fostering a tendency towards rigid beliefs that
16 resist nuanced, evidence-based messages and resulting in hesitancy towards accepting novel
17 medications like the Covid-19 vaccine.

18
19 Evidence shows that conditions of threat and uncertainty amplify cognitive inflexibility
20 (Apergis-Schoute et al., 2023; Korte et al., 2022). Throughout the COVID-19 pandemic, the
21 public encountered substantial challenges in meeting their family doctors face-to-face, relying
22 heavily on news and social media for health information. The surge in social media use
23 exposed the public to highly salient and potentially misleading medical misinformation, often
24 delivered with great certainty, including conspiracy theories that contradicted evidence
25 regarding the safety of vaccines (Burkauskas et al., 2023, Freeman et al. 2022). In this context,

1 individuals identified by the rigidity of their beliefs and ideas, may have endured greater
2 difficulty disregarding these clear, if incorrect, ‘black and white’ messages, which may have
3 ended up being held with greater fixity than the more nuanced scientifically-tuned messages
4 describing the relative balance between safety and efficacy, the potential benefits of
5 vaccination to society as a whole, and the importance of herd immunity in ending the
6 pandemic. Moreover, given the novelty of this type of vaccine, individuals with
7 hypochondriasis or illness anxiety disorder, who are cognitive inflexible, could have avoided
8 vaccination because of excessive worries about their health (Fineberg et al., 2022b).

10 This study suggests therefore that strategies that inform behavioural change in most people
11 (e.g., encouraging social norms that support vaccine acceptance, highlighting the benefits of
12 vaccines and the risks of not getting vaccinated) may not be universally effective, especially
13 for individuals with cognitive inflexibility. On the other hand, strategies that clarify the
14 balance of relevant risks and benefits may be key in improving vaccine uptake in individuals
15 who are hesitant for other reasons e.g., relating to sociodemographic background.

17 Intriguingly, the only measured factor associated with increased risk of vaccine hesitancy
18 was objectively measured (WCST) cognitive inflexibility. The CPAS, a self-rated
19 questionnaire measuring obsessive compulsive traits and in particular item 8, measuring
20 ‘rigidity and stubbornness’, constituting a self-rated proxy of cognitive inflexibility, failed to
21 be a significant predictor. The current study therefore suggests a distinction exists between
22 cognitive inflexibility when measured objectively (using tasks such as the WCST) and self-
23 rated measures that tap aspects of cognitive flexibility (such as the CPAS), possibly indicating
24 lack of self-awareness concerning cognitive traits. Self-rated measures may not be effective in
25 picking-out those cognitive traits underpinning inflexible behavior such as vaccination

1 hesitancy. Individuals might struggle to accurately gauge their cognitive adaptability across
2 various situations, leading to an incomplete portrayal of their flexibility skills. Additionally,
3 social desirability bias could influence self-reports, as individuals may provide responses that
4 align with societal expectations rather than their true cognitive functioning. Individuals with
5 OCPD are known to struggle to recognise their flexibility problems also show poor
6 metacognition and insight regarding this particular cognitive domain (Oltmanns et al., 2005).
7 This underscores the importance of employing objective measures, like computerized
8 neurocognitive tasks, for a more accurate assessment of cognitive inflexibility. The
9 discrepancy between self-perceived and actual cognitive performance, especially on executive
10 tasks, reflects a wider issue. For example, previous studies have shown that monitoring and
11 self-awareness of executive function issues may go undetected by objective assessments
12 (Laws et al., 2008).

13

14 Knowing about cognitive inflexibility could be helpful for public health professionals, GPs
15 and health care workers to better understand the factors determining resistance to vaccine
16 acceptance and protesting attitudes present in this sub-group of the population and adapt
17 educational campaigns accordingly.

18

19 As a longstanding, stable trait developing early in life, and in the absence of recognised
20 remediative interventions, cognitive inflexibility could alternatively be conceptualised as a
21 relatively immutable factor like age, gender, or socioeconomic status. Nevertheless, by
22 investing in translational research to better understanding the origins of the problem and
23 developing reliable objective biomarkers, we may develop new heuristics including the
24 capacity to intervene with yet unidentified forms of preventative intervention in ‘at risk’

1 individuals at the earliest stage, before the inflexibility and its harmful effects have become
2 entrenched.

3
4 As a next step, it would be important to apply agreed definitions and methods to determine
5 more precisely the prevalence and health and societal cost and burden associated with
6 cognitive inflexibility, through the conduct of largescale prospective epidemiological studies
7 including different geographic and cultural groups. Information such as this would be
8 invaluable for addressing contemporary societal issues of great relevance known to be related
9 to inflexible thinking, such as vaccine hesitancy and extreme political partisanship (Fineberg
10 et al., 2021; Zmigrod et al., 2020).

12 **Limitations**

13 We used a vaccine hesitancy scale (OCVHS) specifically designed for evaluating
14 hesitancy to the Covid-19 vaccine in the peri-pandemic phase. This begs the question to what
15 extent this scale and therefore our results apply to other types of vaccination (e.g., measles or
16 flu). While our findings document an association between cognitive inflexibility and hesitancy
17 concerning Covid-19 vaccinations, further research is required before such findings might be
18 generalized to vaccine hesitancy *per se* or indeed, vaccine hesitancy for other specific vaccines
19 (e.g., influenza vaccine). There is the possibility that the vaccine hesitancy measured in our
20 paper is specifically toward the COVID-19 vaccine, being the first one to use a new
21 mechanism based on mRNA and therefore likely to cause more uncertainty than the usual
22 vaccines; this could produce more distress in individuals who are cognitively inflexible (who
23 are known to tolerate less uncertainty). However, even if this was the case, our findings
24 provide useful information for possible future pandemics and the use of new vaccines.

25 We note that perseverative errors (cognitive inflexibility) explain a small amount of
26 variance in vaccine hesitancy. This no doubt reflects the fact that vaccine hesitancy is complex,

heterogenous and multifactorial; and adding one new factor to the overall “vaccine hesitant” profile is likely to be useful and could help explain the mechanism at the origin of this tendency.

Our mean OCVHS score (13.37, SD: 7.17) is very similar to the one reported by Freeman and colleagues (13.6, SD: 7.6) (Freeman et al., 2020), providing some justification of our methodology. We should, however, point out the cross-sectional nature of this analysis as a limitation.

We also note that, like Freeman et al (2022), our sample is relatively educated and so, results may not necessarily be transferable to a wider population. There is the possibility of selection bias in our project, with the sample being recruited online, being composed for the most part of white well-educated women and with a low completion rate of the survey (however, we should also note that this a common issue in studies using online surveys). Education has been negatively associated with number of perseverative as well as non-perseverative and total errors (de Zubicaray et al., 1998; Obonsawin et al., 1999; Rammal et al., 2019). Nonetheless, the levels of education in our sample would seem to rule out perseverative performance on the WCST or indeed, vaccine hesitancy being attributable to lower educational levels and supports inflexibility as an independent factor.

Factors such as psychiatric comorbidities and the use of psychopharmacological medications were not included in our analysis and these could represent confounding factors.

Therefore, our analysis are only exploratory in nature and should be corroborated by further studies investigating the role of cognitive inflexibility on vaccine hesitancy.

Conclusions

1 Cognitive inflexibility characterized by perseverative responding on an objective
2 cognitive task is a relevant contributory factor underpinning vaccine hesitancy and thus a
3 relevant neuropsychological target for innovative public health interventions.

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