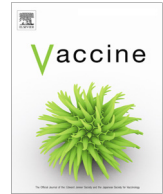




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COVID-19 and seasonal flu vaccination hesitancy: Links to personality and general intelligence in a large, UK cohort



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ABSTRACT

Vaccines are a powerful and relatively safe tool to protect against a range of serious diseases. Nonetheless, a sizeable minority of people express 'vaccination hesitancy'. Accordingly, understanding the bases of this hesitancy represents a significant public health opportunity. In the present study we sought to examine the role of Big Five personality traits and general intelligence as predictors of vaccination hesitancy across two vaccination types in a large (N = 9667) sample of UK adults drawn from the Understanding Society longitudinal household study. We found that lower levels of general intelligence were associated with COVID-19 and seasonal flu vaccination hesitancy, and lower levels of neuroticism was associated with COVID-19 vaccination hesitancy. Although the self-reported reasons for being vaccine hesitant indicated a range of factors were important to people, lower general intelligence was associated with virtually all of these reasons. In contrast, Big Five personality traits showed more nuanced patterns of association.

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1. Introduction

Vaccines are among the most powerful disease-prevention tools medical science has at its disposal [50] and are leading the fight against the spread of COVID-19 [51]. However, despite the success of vaccines in preventing the spread of disease, some individuals oppose their use. For example, recent polls indicate that 20% and 31% of the UK and US populations, respectively, are hesitant to take a COVID-19 vaccine [14,37] (in this paper we use the term vaccine hesitancy to mean a 'delay in acceptance or refusal of vaccines despite availability of vaccine services', taken from MacDonald [28] and vaccine acceptance meaning an intention to use the vaccine if it is, or becomes, available). Beyond COVID-19, vaccination hesitancy is a well-observed phenomenon extending to vaccines for human papillomavirus [55], influenza [53], and measles [56].

These observations of vaccination hesitancy are of substantial medical and social importance as the rejection of vaccines can enable the spread of otherwise preventable diseases [2,19]. For example, vaccination hesitancy can accelerate the rise of new disease variants, which may be resistant to the current suite of vaccines [43]. With this in mind, there is a clear public health need to understand the factors that underpin vaccination hesitancy. Here we pay specific attention to psychological factors that incline an

individual towards vaccine hesitancy. The value of such research likely includes the ability to better identify the kinds of people who are less likely to take a vaccine and why they are reluctant, which in turn would allow for more targeted information to be provided to these individuals that may allay concerns or misunderstandings.

An emerging literature has reported links between Big Five personality traits and vaccination hesitancy across a handful of studies. The Big Five personality traits are a well-validated, high-level description of the major dimensions of human personality [20]. These five dimensions are important because they collectively describe a substantial portion of response variation across the breadth of personality space [30,32]. The Big Five traits consist of neuroticism (e.g. being impulsive, self-conscious, and pessimistic), openness (e.g. being open to new ideas and experiences), conscientiousness (e.g. a preference for order, attention to detail, and self-discipline), agreeableness (e.g. being trusting, compliant, altruistic), and extraversion (e.g. being gregarious, outgoing, optimistic) [58]. These traits are associated with many important life outcomes, such as academic achievement [46], political ideology [15], and well-being [44].

Lin and Wang [23] observed that higher levels of openness, agreeableness, and conscientiousness, and lower levels of neuroticism were associated with a belief in the health benefits of vaccination. Lee et al. [22] reported somewhat similar findings inasmuch as higher levels of agreeableness and conscientiousness

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were related to positive vaccination attitudes; but these authors also observed that *lower* levels of openness were related to positive vaccination attitudes, and no association with neuroticism was found. And Murphy et al. [36] found only higher levels of agreeableness to be predictive of pro-vaccination attitudes in an Irish sample: whereas in a UK sample they found higher levels of agreeableness and conscientiousness, and lower levels of neuroticism to be predictive of pro-vaccination attitudes. Across all of these studies, then, agreeableness and conscientiousness appear to show somewhat consistent links to vaccine sentiment, with tentative evidence for neuroticism and openness.

There are several possible reasons for this variability in findings across studies. Two of these studies examined vaccination for children [22,23], and one examined COVID vaccination [36]. They also examined different populations – the US, New Zealand, and UK and Ireland, respectively. Finally, they measured vaccination in different ways – with two of the studies asking participants whether they would support the idea of vaccination and one study explicitly asking participants if they would get vaccinated.

A range of cognitive traits have also shown links to vaccine sentiment. For example, Murphy et al. [36] identified a negative relationship between vaccination hesitancy and cognitive reflection (operationalised as the ability to choose a correct but cognitively demanding answer over what on the face of it appears obvious but is nonetheless incorrect [13]). And a number of studies have indicated that vaccination hesitancy is associated with so-called ‘omission bias’ [1], a cognitive bias whereby people are inclined to favour inaction over action, even when the relative risks across such decisions are held constant. Furthermore, work by Motta et al. [35] found that those with lower levels of knowledge in a given topic area are more likely to believe themselves to be more knowledgeable than medical experts, which inclines them towards vaccination hesitancy.

Collectively, these findings indicate that individual differences in a range of personality and cognitive traits are likely to be important for understanding why some people are vaccine hesitant. However, a number of open questions remain that the current study sought to address.

Firstly, although associations between Big Five traits and vaccination hesitancy have been reported, the nature of these associations has been somewhat mixed across studies. As detailed above, all of the Big Five traits (bar extraversion) have been linked to vaccination hesitancy. But these associations have not been consistent across studies, with openness even showing changes in direction.

Secondly, while cognitive traits have been linked to vaccination hesitancy, there has been no assessment yet of a role for general intelligence. Yet general intelligence is a clear candidate on several grounds. Firstly, general intelligence is typically considered to reflect the ability to solve complex problems, broadly conceived [18]. The question of whether to support or oppose vaccines would appear, in essence, to be a complex problem, inasmuch as it requires one to appraise and compare the risk probabilities and costs of two different phenomena: the vaccine side effect(s) and the disease itself. More broadly, cognitive reflection scores moderately correlate ($r \approx 0.40$) with a range of numerical ability measures (a facet of general intelligence), but both are independent predictors of performance in decision making tasks [45]. General intelligence is also correlated with educational attainment [10], with links in turn to vaccination attitudes [5,16,34]. Intelligence has also been found to predict a person’s ability to adjust their evaluations of a topic in response to new information that shows their previous evaluations were based upon false information [8]. In the current context of COVID-19, this may impact a person’s ability to navigate COVID-19 misinformation and incline them towards vaccine hesitancy [42].

Finally, little is known of whether predictors of vaccination hesitancy generalise across diseases. On the one hand, Miton and Mercier [33] highlight cognitive obstacles to vaccination, and discuss them in universal terms (e.g., all vaccines require counter-intuitive decision making, they are all informed by the same cognitive biases). On the other, there is evidence for differences between predictors across different vaccinations (e.g. the differences in personality predictors found in [22,36] which examined childhood vaccines and COVID-19, respectively).

To address these issues we used data from ‘Understanding Society’. This large cohort study of UK adults contains measures of Big Five personality traits and general intelligence alongside measures of vaccine hesitancy for two different diseases – COVID-19 and Influenza (no other forms of vaccine hesitancy were available for analysis) – and thus provides an opportunity to examine the association of these psychological predictors with vaccine hesitancy as well as whether these predictors generalise across vaccine types.

2. Methods

2.1. Participants

Understanding Society (<https://www.understandingsociety.ac.uk/>) [52] is a cohort study with a main survey, which is administered every year (currently up to Wave 12). There is also a survey that is specifically centred around the current COVID-19 pandemic which is sent out at irregular intervals to households who complete the main survey (currently up to Wave 3). The Understanding Society cohort is intended to be representative of the UK population over time, through resampling from groups that have dropped out over time [4], and has been shown to closely align with census demographics [25,27,26], and possess higher between-wave response rates compared to other longitudinal studies [3], which helps to preserve representativeness over time. For details of the selection process for Understanding Society see Lynn [24].

We included respondents who had completed Waves 3 (2013) and 9 (2019) of the main survey (as they contained the personality and intelligence variables), and Wave 6 (November 2020) of the COVID-19 specific survey (for vaccination hesitancy and mental health variables). After excluding participants who did not complete each of these waves, the sample used for analysis consisted of 9667 participants. It should be noted that by using these 3 waves that cover the span of 9 years, there may be some selection bias introduced into the sample due to attrition – specifically younger people, men, Black people, and people on lower incomes are more prone to attrition in this sample [27]. A subset of this sample ($N = 1485$) was used for the analysis using the seasonal flu likelihood item, which was only issued to those aged 50–65 years. The main study sample was 58.2% female, with an average age of 54.75 years, and a median education level of A-level or equivalent. The seasonal flu subsample was 56% female, with an average of 53.9 years, and a median education level of A-level or equivalent.

2.2. Measures

2.2.1. COVID-19 vaccination hesitancy

COVID-19 vaccination hesitancy was measured using a single item. Participants were asked to respond to the question *Imagine that a vaccine against COVID-19 was available for anyone who wanted it. How likely or unlikely would you be to take the vaccine?* Note, again, that at the point of assessment no COVID-19 vaccine had been approved for use in the UK and so the participants were responding to a hypothetical. Responses were recorded using a 4-point Likert scale, ranging from 1 = *Very likely* to 4 = *Very unlikely*.

2.2.2. Reasons for declining the vaccine

Participants who indicated they were unlikely or very unlikely to take the COVID-19 vaccine were asked *What is the main reason you would not take the vaccine?* There were 11 options given, as well as one *Other* option. Examples include: *The chances of me catching the coronavirus are low*; and *I am worried about unknown future effects of the vaccine* (see supplementary materials for the full list of reasons).

2.2.3. Seasonal flu vaccination hesitancy

Seasonal flu vaccination hesitancy was measured using a single item, which was given to participants aged 50–65 who had not yet been invited to receive the seasonal flu jab (n = 1433, after removing missing responses). Participants were asked to respond to the question *The Government has indicated that it may offer flu jabs to all those aged 50 – 64 in November and December. If this is offered to you, how likely are you to have a flu jab this autumn/winter?* Responses were recorded using a 4-point Likert scale, ranging from 1 = *Very likely* to 4 = *Very unlikely*.

2.2.4. General intelligence

In line with previous research [9,11], we operationalised general intelligence as the first principal component (which explained 0.39 of the total variance) from the following cognitive tests:

2.2.4.1. *Numerical ability.* Numerical ability was measured using a task adapted from McArdle and Woodcock [31]. This task consists of five questions such as *In a sale, a shop is selling all items at half price. Before the sale, a sofa costs £300. How much will it cost in the sale?* The number of correct answers were used for analysis. A higher score indicated a higher level of numerical ability.

2.2.4.2. *Verbal fluency.* Verbal fluency was measured using a task adapted from Strauss et al. [49]. Participants were asked to list

all the animals that they could think of within 60s. The number of correct answers were used for analysis. A higher score indicated a higher level of verbal fluency.

2.2.4.3. *Number series task.* The number series task was adapted from McArdle and Woodcock [31]. Participants are given up to six sequences of numbers that contain gaps that the participants are expected to fill (e.g. 2,4,?,8,10). A higher score on this measure indicates a greater quantitative reasoning ability.

2.2.4.4. *Subtraction.* Participants were also issued the subtract 7 task, which is a component of the Mini-Mental State Examination (MMSE) [12]. Participants were asked to complete a serial subtraction task where they initially subtracted seven from 100 and then repeated this process on the resulting numbers on five separate occasions (i.e. 93, 86, 79, 72, 65). The number of correct subtractions was used for analysis. A higher score indicates a higher level of subtraction ability.

2.2.4.5. *Delayed and immediate recall.* Memory was measured using a word recall task. Participants were given the following message: *The computer will now read a set of 10 words. I would like you to remember as many as you can. We have purposely made the list long so it will be difficult for anyone to remember all the words. Most people remember just a few.* Participants were then asked to immediately recall the words they had been given. Later on, they received this message: *A little while ago you were read a list of words and you repeated the ones you could remember. Please tell me any of the words that you can remember now.* A higher number of correctly recalled items on each task indicated a better memory. Delayed and immediate recall were included as separate measures in the principal component analysis.

Table 1
Descriptive statistics for study variables.

Variable	Mean	SD	Response options	Valid Percent
COVID-19 vaccination hesitancy	–	–	Very Likely	61.35
			Likely	25.77
			Unlikely	8.13
			Very Unlikely	4.75
Seasonal flu vaccination hesitancy	–	–	Very Likely	40.20
			Likely	28.22
			Unlikely	18.18
			Very Unlikely	13.40
Numerical ability	3.96	0.99		
Verbal fluency	23.8	6.56		
Number series score	2.09	0.89		
Subtraction ability	4.63	0.83		
Delayed word recall	5.76	1.90		
Immediate word recall	6.73	1.49		
Agreeableness	5.62	0.94		
Extraversion	4.54	1.26		
Neuroticism	3.56	1.36		
Openness	4.62	1.17		
Conscientiousness	5.57	0.97		
Self-rated COVID-19 risk	–	–	Very Likely	24.94
			Likely	66.87
			Unlikely	7.36
			Very Unlikely	0.82
Mental health problems	1.56	0.49		
Education	–	–	None	17.68
			Other	1.37
			GCSE	23.03
			A-level	9.53
			Graduate	48.40
Income (month)	2160.57	1743.73		

Note: *Very Likely* indicates very likely to take the vaccine.

2.3. Personality

Big Five personality traits were measured using 15 items taken from the Big Five Inventory (BFI; see [47,57]). This measure consists of five subscales, one for each of the following constructs: agreeableness, extraversion, neuroticism, openness, and conscientiousness. Participants were asked to respond to statements (three per subscale) such as *I see myself as someone who is sometimes rude to others* (Agreeableness [reversed]); *I see myself as someone who is outgoing, sociable* (Extraversion); *I see myself as someone who worries a lot* (Neuroticism); *I see myself as someone who values artistic, aesthetic experiences* (Openness); and *I see myself as someone who does things efficiently* (Conscientiousness). Responses were recorded using a 7-point Likert scale, ranging from 1 = *Does not apply to me at all*, to 7 = *Applies to me perfectly*. The means of each subscale were used for analysis.

2.4. Self-rated COVID risk

Self-rated COVID risk was measured using a single item. Participants were asked to answer the question: *In your view, how likely is it that you will contract COVID-19 in the next month?* Responses were recorded using a 4-point Likert scale, ranging from 1 = *Very likely*, to 4 = *Very Unlikely*, and reverse coded so that a higher score indicated a higher self-rated COVID risk.

2.5. Mental health problems

Mental health problems were measured using the scaled version of the General Health Questionnaire (GHQ12; [17]). This measure consists of 12 items. Participants were asked to respond to questions such as *Have you recently felt that you were playing a useful part in things?* Responses were recorded using a 4-point Likert scale, ranging from 1 = *More so than usual*, to 4 = *Much less than usual*. The means of all the items were used for analysis. A higher score represents greater mental health problems.

2.6. Demographics

Participants were asked to indicate their age, sex, income, and highest level of education. Sex was coded as Male = 0 and Female = 1. We collapsed education into five categories; *none, other (such as vocational qualifications that sit between no education and GCSE), GCSE or equivalent, A-level or equivalent, graduate or other higher degree* (as per [41]). Participants were asked to estimate their income derived from all possible sources (i.e., social benefit, pension, labour income, miscellaneous income, private benefit income, and investment income).

3. Results

Summary statistics for all study variables (not already detailed above) are presented in Table 1.

3.1. COVID-19 vaccination hesitancy (full sample)

We first examined zero-order correlations for COVID-19 vaccination hesitancy. These analyses showed several significant links to COVID-19 vaccination hesitancy. Of the psychological variables, individuals with lower levels of general intelligence and openness, higher levels of neuroticism and self-rated COVID risk and poorer mental health were more likely to be vaccine hesitant. Regarding demographic variables, younger respondents, women, and those with lower education and income were more likely to be vaccine hesitant (see Table 2 for full results).

Table 2
Spearman correlations for COVID-19 vaccination hesitancy using the full sample.

	COVID vaccination hesitancy	Intelligence	Agreeableness	Extraversion	Neuroticism	Openness	Conscientiousness	Self-rated COVID risk	Mental health problems	Age	Sex	Education
COVID vaccination hesitancy												
Intelligence	-0.09**											
Agreeableness	<0.01	-0.08**										
Extraversion	<0.01	<0.01	0.19**									
Neuroticism	0.06**	-0.02	-0.09**	-0.20**								
Openness	-0.06**	0.13**	0.20**	0.25**	-0.11**							
Conscientiousness	-0.01	-0.04*	0.33**	0.21**	-0.16**	0.17**						
Self-rated COVID risk	0.04**	0.04*	-0.02	-0.04**	0.11**	-0.04*	-0.06**					
Mental health problems	0.09**	<0.01	-0.02*	-0.07**	0.35**	-0.01	-0.11**	0.14**				
Age	-0.31**	-0.16**	0.04*	-0.02	-0.18**	0.03*	0.07**	-0.17**	-0.18**			
Sex	0.13**	-0.04*	0.17**	0.13**	0.20**	-0.08**	0.12**	0.07**	0.16**	-0.11**		
Education	-0.06**	0.32**	-0.06**	-0.01	0.02	0.15**	-0.05**	0.03*	0.05**	-0.16**	0.04*	
Income	-0.07**	0.25**	-0.10*	-0.01	-0.12	0.05**	<0.01	0.02*	-0.07**	-0.14**	-0.29**	0.26**

Note: ** = $p < .001$, * = $p < .05$. Male = 0, Female = 1.

Table 3
Ordinal logistic regression model for COVID-19 vaccination hesitancy using the full sample.

Characteristic	OR ¹	95% CI ¹	p-value
Intelligence	0.86	0.83, 0.89	<0.001
Agreeableness	0.96	0.91, 1.02	0.163
Extraversion	0.97	0.93, 1.01	0.143
Neuroticism	0.94	0.90, 0.98	0.002
Openness	0.97	0.93, 1.01	0.144
Conscientiousness	1.03	0.97, 1.09	0.327
Self-rated COVID risk	0.93	0.86, 1.02	0.113
Mental health problems	1.19	1.07, 1.32	0.001
Age	0.95	0.95, 0.95	<0.001
Sex	1.44	1.29, 1.61	<0.001
Education	0.91	0.88, 0.94	<0.001
Income	1.00	1.00, 1.00	<0.001

¹ OR = Odds Ratio, CI = Confidence Interval.

We next conducted an ordinal logistic regression analysis using COVID-19 vaccination hesitancy as the dependent variable and the full collection of demographic, personality, and cognitive traits as independent variables. Of the psychological variables, lower levels of intelligence and neuroticism, and worse mental health predicted greater COVID-19 vaccination hesitancy. Regarding demographic variables, COVID-19 vaccination hesitancy was positively and significantly predicted by being younger, female, and less educated, with a lower income. It should be noted that all of the odds ratios found in the logistic regressions using intelligence, personality, and demographic variables are small in size [7]. For full information, see Table 3.

The ordinal logistic regression model assumes that the link function between each predictor and each category of the dependent variable has the same shape. This can be examined with the Brant test [6,54]. For our key study variables (i.e., general intelligence and Big Five personality traits) we saw no evidence of assumption violations (all *p*'s > 0.05). However, the test indicated potential violations for self-rated COVID risk and mental health problems ($\chi^2_{df=2} = 60.71, p < .001$ and $\chi^2_{df=2} = 9.41, p = .01$, respectively). As such, the reported odds ratio may differ across the levels of these independent variables.

3.2. Seasonal flu and COVID-19 vaccination hesitancy (50–65 years Sub-sample)

We next moved to our sub-sample of 50–65-year-olds for whom we had additional information on seasonal flu vaccination hesitancy. As above, we first examined zero-order correlations. These analyses showed several significant links to seasonal flu vaccination hesitancy: specifically, younger respondents, those with

lower levels of general intelligence and education, and those with higher levels of neuroticism and self-rated COVID-19 risk were more likely to be vaccine hesitant (see supplementary materials for full results). We also performed these analyses for COVID-19 vaccination hesitancy with just the 50–65-year sub-sample to provide a direct comparison (see supplementary materials). The associations between COVID-19 vaccination hesitancy and the demographic variables were broadly as reported in the full sample, with those who are younger, women, less educated and with a lower income being higher in COVID-19 vaccination hesitancy. Of the psychological measures, lower levels of intelligence and worse mental health were associated with greater vaccination hesitancy across both samples. However, self-rated COVID-19 risk was not significantly associated with COVID-19 vaccination hesitancy in the 50–65 sample, and higher levels of agreeableness and extraversion predicted greater COVID-19 vaccination hesitancy.

We next performed two ordinal logistic regression analyses with COVID-19 and seasonal flu vaccination hesitancy as the dependent variables and the full collection of demographic and psychological variables in the 50–65 year sub-sample.

3.2.1. Seasonal flu

Of the psychological variables, lower levels of intelligence and lower levels of self-rated COVID risk predicted greater seasonal flu vaccination hesitancy. Regarding demographic variables, seasonal flu vaccination hesitancy was positively predicted by being younger and less educated. For full information, see Table 4.

3.2.2. COVID-19

Of the psychological variables, lower levels of intelligence predicted greater COVID-19 vaccination hesitancy. Regarding demographic variables, those who were younger, and with a lower education and income had greater COVID-19 vaccination hesitancy. For full information, see Table 4.

As before, we tested for assumption violation using the Brant test. Across seasonal flu and COVID-19 we again saw no evidence of assumption violations for the key study variables (all *p* > .05). However, the test indicated potential violations in the seasonal flu model for income ($\chi^2_{df=2} = 6.89, p = .03$). And in the COVID-19 model, the test indicated a potential violation for self-rated COVID risk ($\chi^2_{df=2} = 10.13, p = .01$). Again, the reported odds ratio may differ across the levels of these independent variables.

3.3. Reasons for vaccination hesitancy

In a final set of steps, we sought to understand a) the reasons given for being hesitant to take the COVID-19 vaccine and b)

Table 4
Ordinal logistic regression models for seasonal flu and COVID-19 vaccination hesitancy in the 50–65 sample.

Characteristic	Seasonal Flu			COVID-19		
	OR1	95% CI1	p-value	OR1	95% CI1	p-value
Intelligence	0.90	0.84, 0.98	0.010	0.82	0.76, 0.89	<0.001
Agreeableness	0.93	0.82, 1.05	0.244	1.05	0.91, 1.21	0.512
Extraversion	1.03	0.94, 1.13	0.553	1.12	1.02, 1.24	0.021
Neuroticism	0.92	0.84, 1.01	0.071	1.03	0.93, 1.13	0.583
Openness	1.02	0.92, 1.13	0.698	0.97	0.87, 1.08	0.571
Conscientiousness	0.98	0.86, 1.11	0.768	0.97	0.85, 1.11	0.669
Self-rated COVID risk	0.74	0.60, 0.90	0.003	0.97	0.79, 1.19	0.753
Mental health	0.93	0.72, 1.20	0.599	1.11	0.85, 1.46	0.440
Age	0.94	0.92, 0.97	<0.001	0.95	0.92, 0.97	<0.001
Sex	0.91	0.71, 1.16	0.432	1.22	0.94, 1.59	0.127
Education	0.86	0.79, 0.93	<0.001	0.89	0.81, 0.97	0.007
Income	1.00	1.00, 1.00	0.346	1.00	1.00, 1.00	0.003

¹OR = Odds Ratio, CI = Confidence Interval.

whether our demographic and psychological variables showed differential prediction across these reasons.

The supplementary materials outline the possible response options and the relative importance of each of these reasons for vaccination hesitancy. The top five specific concerns (i.e., excluding “Other”) were: *I am worried about unknown future effects of the vaccine* (49.70%); *I am worried about side effects* (10.55%); *Vaccines are limited and other people need it more than me* (8.64%); *I don’t trust vaccines* (5.79%); and *The chances of me becoming seriously unwell from the coronavirus are low* (5.27%).

We next conducted a multinomial logistic regression with vaccine acceptance as the reference outcome, and the top 5 reasons to decline vaccination as the other outcomes (which constituted ~ 80% of total responses; all other response options had < 4% (excluding the “Other” responses)), to examine whether our study variables predicted membership to these vaccination hesitancy groups. Descriptive statistics for all study variables across these six categories (i.e. vaccine acceptance and the top 5 reasons for vaccination hesitancy) are detailed in the supplementary materials.

Relative to the vaccine accepters, those that reported vaccination hesitancy due to doubting they would personally become severely unwell from COVID-19 were significantly less agreeable and neurotic, but more conscientious, and (perhaps unsurprisingly) rated themselves to be at a lower risk of catching COVID-19. Those who reported vaccination hesitancy because others need the vaccine more than themselves were more likely to be young and female, significantly less neurotic, rated themselves to be at lower risk of catching COVID-19, scored lower in intelligence, and had better mental health. Those who reported vaccination hesitancy due to the immediate side effects of the vaccine scored lower in intelligence, rated their COVID-19 risk to be lower, had worse mental health, were younger, and more likely to be female. Those who reported vaccination hesitancy because they were concerned about the future effects of the vaccine scored significantly lower in intelligence and extraversion, higher on conscientiousness, and were younger, less educated, and more likely to be

female. Those who reported vaccination hesitancy because they do not trust vaccines scored significantly lower on intelligence, higher in extraversion and openness, had poorer mental health, had a lower self-rated COVID-19 risk, were younger, less educated, and more likely to be female. Full results are detailed in [Table 5](#).

3.4. Discussion

The current study sought to address several outstanding questions concerning the psychological bases of vaccination hesitancy: specifically, the nature of any links to general intelligence and Big Five personality traits; whether predictors of vaccination hesitancy in the context of COVID-19 are also seen for vaccination hesitancy in the context of seasonal flu; and whether predictors of COVID-19 vaccination hesitancy differ across the (self-reported) motives for being hesitant.

Lower intelligence had a small but consistent association with greater vaccination hesitancy across both samples, and both types of vaccine. This observation is in line with findings that those with a more intuitive style of cognition were less likely to vaccinate, those with a more analytical style of cognition were more likely to vaccinate [29], and those with lower cognitive sophistication scores were more susceptible to vaccine misperceptions [38]. However, given intelligence’s modest correlation with cognitive styles [45], it appears that intelligence provides a meaningful, independent contribution to understanding vaccination hesitancy.

In contrast, the roles of Big Five personality traits in COVID-19 vaccination hesitancy were more mixed. When examining COVID-19 vaccination hesitancy in our full sample, we observed positive zero order correlations with neuroticism and openness. However, we noted in the regression a reversal of the neuroticism relationship direction (from a positive association with greater vaccination hesitancy, to a negative association). These findings contrast with those reported in the literature: Lee et al. [22] and Murphy et al. [36] reported no link between neuroticism and vaccination hesitancy. The lack of association between openness and vaccination hesitancy contrasts with Lin and Wang [23] and Lee

Table 5
Multinomial logistic regression for reasons underlying COVID-19 vaccination hesitancy.

Variable	OR ¹	95% CI ¹	p-value	OR ²	95% CI ²	p-value	OR ³	95% CI ³	p-value	OR ⁴	95% CI ⁴	p-value	OR ⁵	95% CI ⁵	p-value	OR ⁶	95% CI ⁶	p-value
	2			3			4			5			6					
Intelligence	0.92	0.76, 1.11	0.37	0.79	0.69, 0.91	0.001	0.71	0.63, 0.81	<0.001	0.89	0.84, 0.95	<0.001	0.78	0.66, 0.92	0.004			
Agreeableness	0.78	0.65, 0.93	0.006	0.86	0.69, 1.07	0.17	0.99	0.83, 1.18	0.92	1.01	0.85, 1.19	0.95	0.93	0.86, 1.01	0.07	1.3	1.04, 1.63	0.023
Extraversion	0.88	0.71, 1.09	0.26	0.99	0.83, 1.18	0.92	1.01	0.85, 1.19	0.95	0.93	0.86, 1.01	0.07	1.3	1.04, 1.63	0.023			
Neuroticism	0.75	0.62, 0.90	0.002	0.83	0.72, 0.95	0.009	1.03	0.90, 1.16	0.7	0.95	0.88, 1.02	0.15	1	0.85, 1.17	0.97			
Openness	1.05	0.83, 1.34	0.69	0.94	0.78, 1.13	0.48	1.03	0.86, 1.23	0.73	0.96	0.88, 1.04	0.33	1.33	1.05, 1.68	0.019			
Conscientiousness	1.14	1.02, 1.28	0.021	1.05	0.84, 1.31	0.67	0.96	0.78, 1.18	0.7	1.15	1.03, 1.28	0.011	0.8	0.62, 1.04	0.1			
Self-rated COVID risk	0.6	0.59, 0.62	<0.001	0.7	0.69, 0.72	<0.001	0.73	0.72, 0.74	<0.001	0.9	0.77, 1.06	0.2	0.26	0.26, 0.27	<0.001			
Mental health problems	1.21	1.17, 1.25	<0.001	0.91	0.89, 0.94	<0.001	1.12	1.09, 1.14	<0.001	1.07	0.89, 1.29	0.48	2	1.92, 2.07	<0.001			
Age	0.91	0.89, 0.93	<0.001	0.94	0.93, 0.95	<0.001	0.95	0.94, 0.97	<0.001	0.95	0.94, 0.96	<0.001	0.96	0.95, 0.98	<0.001			
Sex	1.23	1.19, 1.28	<0.001	1.39	1.35, 1.43	<0.001	1.04	1.01, 1.07	0.008	1.85	1.47, 2.34	<0.001	1.44	1.38, 1.50	<0.001			
Education	1.01	0.82, 1.25	0.9	0.99	0.85, 1.15	0.87	0.97	0.84, 1.12	0.68	0.91	0.85, 0.98	0.01	0.79	0.67, 0.94	0.009			
Income	1	1.00, 1.00	0.68	1	1.00, 1.00	0.063	1	1.00, 1.00	0.015	1	1.00, 1.00	0.027	1	1.00, 1.00	0.12			

Note: 1 = Vaccine acceptance, 2 = I am worried about unknown future effects of the vaccine, 3 = I am worried about side effects, 4 = Vaccines are limited and other people need it more than me, 5 = I don’t trust vaccines, 6 = The chances of me becoming seriously unwell from the coronavirus are low.

et al. [22], who found significant associations. As noted earlier, psychological correlates of vaccine hesitancy may vary across situation, country, and measure. As such we recommend replication across these parameters.

In the 50–65 age group, there are several noteworthy differences in the relationship between psychological traits and vaccination hesitancy compared to the main sample. Firstly, neuroticism was not predictive of COVID-19 vaccination hesitancy in this group. This may be due to the increased risk that the virus presents to this age category, which may suppress any association between trait-level neuroticism and vaccination hesitancy. Secondly, extraversion was a significant predictor of COVID-19 vaccination hesitancy in the 50–65 age group, but not in the main sample. We do not have a compelling explanation for this observation.

Beyond personality and general intelligence, we also observed additional demographic variables predictive of COVID-19 vaccination hesitancy. Results from our regression analyses indicated that younger respondents, women, those with lower incomes, education, and poorer mental health were more likely to be vaccination hesitant. We saw similar results for seasonal flu vaccination hesitancy (note, restricted to 50–65 year olds): being younger and less educated predicted hesitancy. Furthermore, we noted an unexpected relationship between self-rated COVID risk and vaccination hesitancy, with greater self-rated risk being associated with greater hesitancy. At the face of it one might expect this relationship to be reversed. One possibility is that self-rated risk reflects a more generalised anxiety, which in turn leads to a fear of needles (or other barrier to getting vaccinated). Of note, the relationship between self-rated COVID risk and vaccination hesitancy was in the expected direction in the ordinal logistic regression where neuroticism was also modelled, which is consistent with this account.

In our multinomial logistic regression model, intelligence was a significant negative predictor for all but one of the reasons (worry over the future effects of the vaccine) that people chose to decline COVID-19 vaccination. Big Five traits differentially predicted reasons to decline COVID-19 vaccination. For example, participants with higher levels of conscientiousness were more distrustful of the vaccine, those with lower levels of neuroticism were worried about the vaccine's effects (presumably more than the virus symptoms), and those with higher levels of openness and extraversion doubted the level of risk presented by the virus.

The multinomial logistic regression findings should be interpreted with a degree of caution due to the relatively small samples in some of these categories. Nonetheless, these results may help to explain mixed results between personality traits and vaccination hesitancy across studies. That is, if a given sample happens to have more individuals who distrust vaccines vs fear side-effects, then the profile of predictors may well look very different. These findings, then, represent an important observation in their own right with regard to understanding the underlying bases for being vaccine hesitant, but also indicate future work on this topic should assess the reasons people have for opposing vaccines and not simply assess vaccination hesitancy alone.

Some limitations of the current study bear mention. Firstly, we used short-form Big Five personality scales, which provide lower fidelity assessment of personality traits than would be desirable. That said, this approach is recommended in large, cohort settings where long-form instruments cannot be easily administered. Moreover, these short form measures have been shown to correlate highly with longer form measures (e.g. [39,48,47]; although we did not have the opportunity to validate this observation in the current sample). Secondly, while we had access to an important set of candidate predictors, clearly there are other factors that shape vaccination hesitancy that were not available in the dataset. Future work should consider including factors such as pathogen disgust sensitivity and political ideology. Thirdly, the associations

found with seasonal flu vaccination hesitancy may be partly explained by the current COVID-19 pandemic, which has resulted in people taking up more preventative health measures [21,40]. The seasonal flu vaccine represents a preventative health measure, as it would be protective against a flu infection occurring at the same time as a potential COVID infection, which may lead to associations carrying over from COVID to flu. This possibility is supported by the large correlation between seasonal flu and COVID-19 vaccination hesitancy. However, from our regression results in the sub-sample, there appear to be some unique differences in their relationships to our predictor variables.

In summary, general intelligence is a significant predictor of COVID vaccination hesitancy, which generalises to at least one other form of vaccination. There is also a degree of heterogeneity in predictors of specific motivations to be vaccine hesitant. However, the predictors of vaccination hesitancy across vaccination types are largely homogeneous. These results provide an important and nuanced insight into vaccination hesitancy and help to reconcile some of the inconsistencies found in previous literature.

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 material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.vaccine.2022.05.062>.

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