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Consumer impatience: A key motive for Covid-19 vaccination

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ABSTRACT

We study the behavioral determinants of COVID-19 vaccination uptake. The vaccine-pass policy, implemented in several countries in 2021, conditioned the access to leisure and consumption places to being vaccinated against COVID-19 and created an unprecedented situation where individuals' access to consumption goods and vaccine status were interrelated. We rely on a quasi-hyperbolic discounting model to study the plausible relationships between time preference and the decision to vaccinate in such context. We test the predictions of our model using data collected from a representative sample of the French population ($N = 1034$) in August and September 2021. Respondents were asked about their COVID-19 vaccination status (zero, one, or two doses), as well as their economic and social preferences. Preference elicitations were undertaken online through incentivized tasks, with parallel collection of self-stated preferences. Factors associated with COVID-19 vaccination were investigated using a logistic model. Both elicited and stated impatience were found to be positively associated with COVID-19 vaccination decisions. These results suggest that impatience is a key motivational lever for vaccine uptake in a context where the vaccination decision is multidimensional and impacts the consumption potential. Results also serve to highlight the potential effectiveness of public communications campaigns based on time preferences to increase vaccination coverage.

1. Introduction

Behavioral economics of vaccination is a growing topic (Betsch, Böhm, & Chapman, 2015). Risk preferences and social preferences are obvious factors for predicting vaccination behavior, but time trade-offs might be also at stake: according to standard economic models, people trade off the current cost (of vaccination) with future benefits (of immunization) .[1] Such a trade-off is grounded on individuals' subjective discount factor. People who discount future benefits more heavily are less likely to opt for vaccination and to incur its costs at the present time. Evidence of such trade-offs was provided by Chapman (1999) and Tsutsui, Benzion, Shahrabani, and Din (2010) regarding influenza vaccines, or by Nan and Kim (2014) for the H1N1 pandemic influenza vaccine. In this paper, we will focus on the time trade-offs determining uptake of the COVID-19 vaccination; we will obtain that, surprisingly, the role of time trade-offs in determining uptake is reversed: heavy discounters are more eager to get vaccine.

With respect to the COVID-19 vaccine, evidence of a link between impatience and vaccination is mixed. The study by Blondel, Chyderiotis, Langot, Mueller, and Sicsic (2022) is, as ours, based on a French general population sample: a significant effect of impatience on the decision to vaccinate was studied, but not found (here the study relies on a non-incentivized experimental measure). This is also the case for the studies by Okubo, Inoue, and Sekijima (2021), Tanaka, Nihonsugi, Ohtake, and Haruno (2021) and Wismans et al. (2021) among large Japanese cohorts and European students. These studies, which relied on hypothetical choices to elicit time preferences, did not find any significant relationship between time preferences and the intention to vaccinate. On the contrary, Ma and Ma (2022), and Guillon and Kergall (2021), found a positive association between intention to vaccinate and the Consideration of Future Consequences Scale (which is sometimes taken as a proxy for patience), based respectively on samples from the US general population and from the French general population. Finally, Hudson, Hall, Hitchman, Meng, and Fong (2023) found that Canadian adults with substantial impulsivity or delay discounting were more likely to be unvaccinated or to be partially vaccinated, with no intention

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[1] More generally, impatience is a key driver of many health decisions, such as preventive behaviors (see, e.g., Bradford et al., 2017).

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of being fully vaccinated.

The ambivalence of these results demonstrated the need for further research. In this paper, we follow two directions. First, we reinvestigate the theoretical economic reasoning around the vaccination decision in the context of the vaccine-pass implemented by several European countries in 2021. The implementation the vaccine-pass created a novel situation that closely linked access to consumptions goods to the vaccination status. We introduce a quasi-hyperbolic discounting model to examine the new plausible relationships between individuals' preferences and their vaccination decision. We obtain that, when the vaccine-pass is in force, more impatient individuals will tend to suffer more from the restrictions on immediate consumption; and, logically, remaining unvaccinated comes at higher cost for them. Besides, as the available empirical evidence on the link between COVID-19 vaccination and time preferences is mixed, partly because the elicitation tools used to assess time preferences were less robust in studies conducted in emergency in early 2020, our paper offers new evidence by means of validated incentivized tasks as well as validated questionnaires. This was achieved by using both a standard self-stated preference measure of patience (Vischer et al., 2013) and the Convex Time Budget method (hereafter CTB) (Andreoni & Sprenger, 2012), where non-constant discounting is also considered. Indeed, besides standard discounting, the behavioral economics literature showed that many people are time-inconsistent (e.g., Laibson, 1997; Loewenstein & Prelec, 1992; Thaler, 1981; Frederick, Loewenstein, & O'donoghue, 2002), tending to be present- or future-biased.

Our study focuses on COVID-19 vaccination in France during late summer 2021. In France, the vaccination was free of charge for the population. The vaccination campaign started in January 2021 and was conducted in several steps, beginning with the vaccination of institutionalized elderly followed by the vaccination of targeted populations at risk of severe COVID-19 infection. Vaccination was made available to the population aged between 50 and 64 years old on May 2021 10th, to all adults with no age condition but based on doses availability from May 2021 12th, and finally to all adults less than 50 years old with no restriction from May 31st 2021. After a progressive scaling-up of the vaccine distribution, with local waiting-time due to shortages of doses at the beginning of the process, adults in France could access COVID-19 vaccination after May 2021 with no more restrictions on vaccines availability across the whole territory (In a recent publication by the French Ministry of Health, social disparities are emphasized, though not in conjunction with the supply infrastructure). At the beginning of June 2021, a health passport - including either a vaccination certificate, a proof of a negative COVID-19 test or a medical certificate of COVID-19 recovery - was implemented in France for gatherings of more than 1000 people. This health passport, seen in practice as a 'vaccine-pass', was extended to most places of shopping, leisure, or culture in July 2021. By September 1st 2021, more than 49 million people, mainly adults at that time, received at least one COVID-19 vaccine dose in France.

The rest of the paper is organized as follows. Section 2 theoretically explores the link between time preferences and COVID-19 vaccination decision in the context of the health pass. Section 3 presents the material and methods for the empirical study and Section 4 displays the empirical results which are discussed in Section 5.

2. The intertemporal consumption choice of the agent and her vaccination status

In this section, we propose a model of intertemporal consumption where the vaccination status of the agent and her time-preferences are interrelated. Although the traditional economic reasoning about vaccine uptake emphasizes a negative relationship between vaccine uptake and impatience (Shahrabani, Gafni, & Ben-Zion, 2008; Tsutsui et al., 2010), our data shows a (somewhat unusual) positive association between individuals' impatience and their COVID-19 vaccine uptake. We thought we had to offer a theoretical framework that fits these data.

For parsimony, we consider a 3-period intertemporal consumption model, based on the quasi-hyperbolic discounting model of Laibson (1997), also called the β−δ model. Three is the minimum number of periods to allow present (future) bias to play a role in the decision to vaccinate. We rely on a constant relative risk-aversion (CRRA) utility function. C_t represents the value of period t consumption and ρ is the CRRA parameter:

$$U(C_t) = \begin{cases} \dfrac{C_t^{1-\rho}}{1-\rho} \ if\ \rho \neq 1 \\ LogC_t \ if\ \rho = 1 \end{cases}$$

To facilitate reading, we report only the predictions for the case $\rho = 1$ and relegate the general case to Appendix A.

The main mechanism relates to the vaccine-pass policy, which creates a constraint on immediate consumption for non-vaccinated agents (period 1 consumption) and affects their allocation decision on intertemporal consumption flows. The model will demonstrate that the most impatient agents are the more affected by this consumption constraint, i.e., agents with lower δ or lower β are more strongly affected by current consumption restrictions. Consequently, they are more prone to get vaccinated against COVID-19. We first present the optimization problem for an agent with a vaccination pass before considering the corresponding problem for an agent without this pass.

2.1. Intertemporal choice of an optimizing individual with a vaccine-pass

Let W^{vac} be the discounted utility of a vaccinated agent over the three periods:

$$W^{vac} = U(C_1) + \beta.\left[\delta.U(C_2) + \delta^2.U(C_3)\right]$$

s.t.

$$\Omega = C_1 + \frac{C_2}{1+r} + \frac{C_3}{(1+r)^2}$$

With C_t the flow of consumption in period t, Ω the total income (exogenous) and r the interest rate. δ is the standard discount rate ($\delta \in (0,1]$), β corresponds to the present bias parameter of the quasi-hyperbolic discounting model. We assume $\beta > 0$. If $\beta < 1$ the agent is present biased, if $\beta > 1$ she is future biased, and if $\beta = 1$ she is time consistent. As δ and β tend to zero the agent becomes increasingly impatient.

The Lagrangian of the optimization program is (see Appendix A for details of the Lagrangian program):

$$L^{vac} = U(C_1) + \beta.\left[\delta.U(C_2) + \delta^2.U(C_3)\right] + \lambda\left[\Omega - C_1 - \frac{C_2}{1+r} - \frac{C_3}{(1+r)^2}\right]$$

Table 1 provides the optimal levels of consumption for the three periods for the vaccinated agent using the log utility function.

2.2. Intertemporal choice of an optimizing individual without a vaccine-pass

In practice, the lack of a vaccine-pass by non-vaccinated individuals

Table 1
Optimal levels of consumption for the three periods for the vaccinated agent.

For $\lambda > 0$	$U(C_t) = \log(C_t)$
C_1^{vac*}	$\dfrac{1}{1+\beta.\delta.[1+\delta]}\Omega$
C_2^{vac*}	$(1+r).\beta.\delta.\left(\dfrac{1}{1+\beta.\delta.[1+\delta]}\right)\Omega$
C_3^{vac*}	$(1+r)^2.\beta.\delta^2.\left(\dfrac{1}{1+\beta.\delta.[1+\delta]}\right)\Omega$

was associated with restrictions on the immediate flow of consumption. Those restrictions - linked to limited access to public and leisure places, shopping malls, restaurants, etc., and strong restrictions in travelling - impose a limit to C_1, that we model as a constraint on present consumption[2]: $C_1 \leq \overline{C}_1$. The discounted utility of an unvaccinated agent over the three periods, noted W^{unvac}, is:

$$W^{unvac} = U(C_1) + \beta.\left[\delta.U(C_2) + \delta^2.U(C_3)\right]$$

s.t.

$$\Omega = C_1 + \frac{C_2}{1+r} + \frac{C_3}{(1+r)^2}$$

$$C_1 \leq \overline{C}_1$$

The Lagrangian is (see Appendix A for details of the Lagrangian program):

$$L^{unvac} = U(C_1) + \beta.\left[\delta.U(C_2) + \delta^2.U(C_3)\right] + \lambda\left[\Omega - C_1 - \frac{C_2}{1+r} - \frac{C_3}{(1+r)^2}\right] + \mu(\overline{C}_1 - C_1)$$

The interesting case emerges when the constraint $C_1 \leq \overline{C}_1$ is binding and when $\overline{C}_1$ is sufficiently low. This is the situation that most unvaccinated individuals were facing when the government decided to activate the vaccine-pass. Those without the pass encountered sharp restrictions on their current consumption. For $\mu > 0$, Table 2 provides the optimal levels of consumption for the three periods for the unvaccinated agent using the log utility function.

2.3. *Comparing the two equilibria: evaluating the cost of remaining unvaccinated*

The comparison of the models for vaccinated and unvaccinated agent brings interesting results. First, let us comment about the importance of the consumption gap in period 1 for the unvaccinated agent that is presented in Table 3 for the case of the log utility function, i.e. $C_1^{vac*} - C_1^{unvac*} = C_1^{vac*} - \overline{C}_1$.

This gap precisely measures the intensity of the restriction imposed on the current consumption of the unvaccinated agents, i.e., the difference between their planned (desired) consumption C_1^{vac*} and the consumption $\overline{C}_1$ exogenously imposed. This gap also corresponds to "forced savings". Note that the saving rates tend to increase sharply during sanitary restrictions (Bignon & Garnier, 2020; Dauvin et al., 2020).

LEMMA 1. *Forced savings ($C_1^{vac*} - \overline{C}_1$) increase as the unvaccinated agent becomes more impatient,* i.e. *as either δ, β, or both, decrease.*

We also note an increase in forced savings as the Ω parameter rises.

Table 2
Optimal levels of consumption for the three periods for the unvaccinated agent.

For $\lambda > 0$ and $\mu > 0$	$U(C_t) = \log(C_t)$
C_1^{unvac*}	$\overline{C}_1$
C_2^{unvac*}	$\frac{1+r}{1+\delta}.(\Omega - \overline{C}_1)$
C_3^{unvac*}	$(1+r)^2.\delta.\frac{1}{1+\gamma}.(\Omega - \overline{C}_1)$
μ^*	$\frac{1}{\overline{C}_1} - \frac{\beta.\delta.(1+\delta)}{\Omega - \overline{C}_1}$

[2] In practice, the constraint has been applied for a period of 9 months in France (June 2021 – March 2022).

Table 3
Consumption gap in period 1 for the unvaccinated agent.

Consumption gap (forced saving)	$U(C_1) = \log(C_1)$
$C_1^{vac*} - \overline{C}_1$	$\frac{\Omega}{1+\beta.\delta.[1+\delta]} - \overline{C}_1$

This suggests that individuals with higher incomes, and consequently greater access to market goods, experience a more pronounced impact from the consumption constraint resulting from non-vaccination. This observation is consistent with our empirical findings, which indicate a higher inclination for vaccination among individuals with higher incomes. Furthermore, our results reveal a significantly lower predicted probability of vaccination among respondents with low incomes, particularly for high values of stated and elicited time preference.

Examining the Lagrangian provides insights into the welfare implications associated with remaining unvaccinated. The optimal value of the Lagrangian multiplier μ^* represents the marginal cost of the period 1 consumption constraint on individuals' welfare (the shadow price of the constraint imposed by the vaccine-pass). One can see that the value of μ^* is increasing as far as δ and β are decreasing. This means that the marginal impact on welfare of the consumption constraint $C_1 \leq \overline{C}_1$ is stronger for more impatient agents. This is stated as lemma 2.

LEMMA 2. *The shadow price μ^* of the period 1 consumption constraint ($C_1 \leq \overline{C}_1$) increases with decreasing values of both δ and β.*

An additional method to measure the consequence of the constraint on period 1 consumption ($C_1 \leq \overline{C}_1$) is to quantify the welfare gap experienced by an agent choosing to remain unvaccinated.

$$\begin{aligned} W^{vac} - W^{unvac} &\equiv W^{vac}\left(C_1^{vac}, C_2^{vac}, C_3^{vac}\right) - W^{unvac}\left(C_1^{unvac}, C_2^{unvac}, C_3^{unvac}\right) \\ &= L^{vac} - L^{unvac}|\left\{C_t^{vac}, C_t^{unvac}\right\}_{t=1}^{3} \end{aligned} \quad (10)$$

PROPOSITION 1. *As the agent becomes more impatient, indicated by a decrease in either δ, β, or both, her welfare-cost ($W^{vac} - W^{unvac}$) of remaining unvaccinated increases.*

The proof of Proposition 1, reported in Appendix A, is based on the calculation of the total derivative of the welfare gap $L^{vac} - L^{unvac}|\{C_t^{vac*}, C_t^{unvac*}\}_{t=1}^{3}$ when δ *or* β vary.

Lemmas 1 and 2, as well as Proposition 1, also apply to the general CRRA utility function with $\rho \neq 1$ (see Appendix A).

Proposition 1 is the main output of our theoretical setting: the constraint on consumption in period 1 ($C_1 \leq \overline{C}_1$) is a substantial reason that presses the more impatient individuals to take-up the vaccine. We acknowledge that we propose only a partial model of the vaccination decision that focuses exclusively on the expected effect of the vaccine on individuals' consumption, neglecting the effect on their health status. However, it is enough to demonstrate that the sign of the relationship between time preferences and the individual vaccination decision is considerably renewed by the existence of the vaccine-pass policy.

3. Material and methods for the empirical study

The collection of data was conceived with the general purpose of correlating economic preferences (experimentally elicited or assessed using validated questionnaires) with reported health behaviors of large samples of population (observed in the field). The recruitment of a representative sample of the French population was undertaken by an independent panelist (https://www.institut-viavoice.com) in August and September 2021, using quota sampling based on gender, age, region, and socio-professional category. The sample used in the analysis was comprised 1034 French-speaking adults living in France. To implement the questionnaire, we used the platform O-Tree (https://www.otree.org), especially suited to behavioral research and experiments. The median duration for completing the survey was 42 minutes. Participants who completed the survey received a payment for their participation that was around €10. Regarding the payment of the experimental tasks, a total of 172 participants were selected for payment and received an average of €28.89. The Ethics Committee of Aix-Marseille University reviewed the study and gave the green light to proceed (June 2021).

The dependent variable was self-reported COVID-19 vaccination status. Respondents were asked how many COVID-19 vaccine doses they had received at the time of the survey. We created a dichotomous variable equal to 1 if respondents had received at least one COVID-19 vaccine dose, and 0 otherwise.

Explanatory variables of interest include risk preference, time preference (ordinary discounting and time inconsistency) and social preference (prosociality and trust). Table 4 gives an overview of the incentivized tasks and self-reported questions used to measure time, risk, and social preferences. For incentivized tasks, participants were told that they had a chance over four for being selected for payment and would be paid based on the decisions made in one of the tasks (each task had the same probability of being selected). We start by describing the incentivized tasks for time, risk and social preferences before turning to stated preference questions.

In the CTB task participants had to allocate €40 between a 'sooner' and a 'later' date, one month apart. They could choose any allocation, e. g. between 0 and 40 in integer amounts, at any date.[3] The task was repeated twice. The initial sequence (version 1) was the following. In task one, the sooner date was shortly after the survey date, September 30th, while the later date was October 30th. In task two, the dates of task one were delayed by one month: the sooner date was October 30th and the later November 30th. Because the survey was effective from August 25th to October 11th, we had to postpone this initial sequence. We created a second version of questionnaire (version 2) for participants who received the web-link after the 20th of September. In this second version the sequence was the following. In task one, the sooner date was October 15th, while the later date was November 15th. In task two, the dates of the task were delayed by one month: the sooner date was November 15th and the later December 15th. In practice, 839 participants who started the survey between August 24th and September 19th responded to the first version of the CTB task and the remaining 199 participants, who started the survey after September 19th, responded to the second version of the CTB tasks. Participants were informed that each euro invested at the sooner date was worth one euro, while each euro invested at the later date had an augmented value of 1.2 euro. The share of money invested at the later date in the second decision was taken as an indicator of patience. A comparison of the amount allocated to the sooner date in both decisions was used as a measure of time consistency; those respondents who invested the same amount at the sooner date in both decisions could be categorized as 'time-consistent'. Those who allocated more (less) at the sooner date in task one than in task two can be seen to exhibit decreasing (increasing) impatience and were categorized as 'present-biased' ('future-biased').

We used the portfolio choice task of Gneezy and Potters (1997) as an incentivized measure of risk preference. The portfolio choice task provided participants with a €20 endowment that they had to allocate between a safe asset (keeping the money) and a risky asset. The amount invested in the risky asset was multiplied by three or by zero, with a probability of one half, respectively. We used the share of the endowment allocated to the risky asset as a measure of risk tolerance.

Respondents' concern for others was captured by their social value orientation (SVO, Murphy et al., 2011). Respondents had to select an allocation of cash (among a set of six possible allocations) between themselves and an unknown randomly selected participant. The choice was repeated six times, with different sets of allocations. The SVO angle provides an indicator of prosociality and was calculated using the following formula:

$$\text{SVO} = Arctan\left(\frac{As - 50}{Ao - 50}\right)$$

where As is the average amount allocated to self and Ao the average amount allocated to other (over the six tasks).

Regarding stated preference questions, patience was assessed by asking respondents to rate their general level of patience on a scale from 0 (very impatient) to 10 (very patient). Willingness to take risk in general and in the health domain were assessed by asking respondents to rate their willingness to take risks in general/in the health domain on a scale from 0 (not at all willing to take risks) to 10 (very willing to take risks). Finally, respondents were asked to rate their level of trust in general, in their colleagues and in their family members on a scale from 0 (very careful) to 10 (very confident). A trust score was created by averaging responses to these three questions (Cronbach's alpha = 0.7689).

Your statement is clear and informative. If you'd like a slight refinement for flow and conciseness, you might consider:

To mitigate the risk of omitted variable bias, we incorporate standard controls widely acknowledged as pertinent to vaccination uptake, including gender, age, place of residence, health status (both self and household members), education, and income, in all regression analyses (Jain, Van Hoek, Boccia, & Thomas, 2017). More specifically, control variables include gender, age, a binary variable for respondents living in a rural city or in city of less than 10,000 inhabitants, education level, monthly income and two binary variables for respondents with a risk of a severe COVID-19 form (equal to 1 if the respondent had a chronic disease that makes her/him at risk of a severe COVID-19 form and 0 otherwise) and for respondents who shared their household with an individual at risk of a severe COVID-19 form. Age was coded as a three-modality categorical variable (18–49 years old, 50–64 years old and 65 years old or more) .[4] The education level was coded as a categorical variable with the following response modalities: lower than A-Level (reference category), A-Level, between A-Level and bachelor's degree, and master's degree or PhD. Monthly income was coded as a categorical variable with four modalities: €0 to €2000 (reference category), €2001 to €4000, more than €4000, and "do not know" or "do not wish to answer".

Factors associated with COVID-19 vaccination were investigated

Table 4
Description of preference measures.

Preferences	Incentivized tasks	Stated preference questions
Time preference	Convex time budget task (Andreoni & Sprenger, 2012)	Patience in general (Likert-type scale from 0 to 10) (Vischer et al., 2013)
Risk preference	Portfolio choice task (Gneezy & Potter, 1997)	Willingness to take risk in general (Likert-type scale from 0 to 10) Willingness to take risk in health (Likert-type scale from 0 to 10) (Dohmen et al., 2011)
Social preference	Prosociality Social Value Orientation (Murphy, Ackermann, & Handgraaf, 2011)	Mean level of trust in general, family members and colleagues (α = 0.77) *Adapted from European Social Survey (ESS)*

[3] The allocation was determined by moving a cursor that was initially posited in the middle. By moving the cursor to the left the amount at the sooner date increased while that at the later date decreased by an equivalent amount. Moving the cursor to the right had exactly the opposite effect.

[4] Age was also inserted as a continuous variable or as a binary variable for respondents aged 65 years old and more in regression analyses. Our results on preferences are robust to the use of alternative coding of age.

using a logistic model. To test the robustness of the results, regressions were conducted using the incentivized and self-reported measures of time and risk preferences alternately. The analysis then turned to incentivized preference indicators and introduced time inconsistency as a variable of interest. The time consistency variable was not directly introduced in the regression as an independent variable given its significant correlation with the share of money invested at the later date in the second CTB decision, thus potentially generating a collinearity problem. Instead, as patience and time inconsistency appeared to have a multiplicative effect in the theoretical model, we ran regression analyses stratified by time consistency categorization. All regression analyses were run using Stata® 16.

4. Results

Table 5 presents the summary statistics for the dependent and preference variables used in regression analyses. Table B1 in Appendix B displays sample characteristics for control variables. Table B2 and B3 assess representativeness of the sample in terms of living area, age and sex. Table B4 presents correlation matrix between time, risk and social preferences measures and Figure B1 displays the distributions of the share of money allocated to the second date in both CTB decisions. Only 10.12% of respondents had received no COVID-19 vaccine dose. Respondents are less willing to take risks in the health domain (3.05) than in general (4.72). On average, participants allocated 69.28% of their allotted money on the later date in the second CTB decision. More than half of respondents (55.49%) are time-consistent while almost a quarter is present-biased (23.51%) and a fifth is future-biased (21.00%).[5]

Table 5
Descriptive statistics.

Variable	Mean	SD	Min	Max	N (%)
COVID-19 vaccination					
Yes					933 (89.88%)
No					105 (10.12%)
Money allocated to the risky asset (%)	43.60	36.90	0	100	
Willingness to take risk in general	4.72	2.44	0	10	
Willingness to take risk in health	3.05	2.45	0	10	
Money allocated to the second date (%, second CTB decision)	69.28	30.94	0	100	
Time consistency categorization					
Time-consistent					576 (55.49%)
Present-biased					244 (23.51%)
Future-biased					218 (21.00%)
Stated patience	5.90	2.57	0	10	
Prosociality (SVO angle)	30.95	13.22	−16.26	61.39	
Trust score	5.80	2.14	0	10	

Table 6 presents the regression results for COVID-19 vaccination in the full sample. To assess the robustness of our findings against potential omitted variables, we present results for three specifications for each combination of time and risk preference measures: (a) with all controls, (b) without controls for risk and social preferences, and (c) with no controls at all. We find no significant associations between social preferences (prosociality and trust) and vaccination. A negative association is found between the willingness to take risk - both in general and in the health domain - and COVID-19 vaccination. On the contrary, no significant effect is found between the share of money allocated to the risky asset in the incentivized portfolio task and COVID-19 vaccination. Patience, either measured through the incentivized CTB task or through the self-reported question, is negatively associated with COVID-19 vaccination. The regression coefficients associated with time preference measures exhibit a high degree of stability even when controls are omitted from the analysis. With respect to social preferences, neither prosociality nor trust are significantly linked with COVID-19 vaccination. Respondents over 65 and those with higher incomes are more likely to be vaccinated, while respondents living in rural areas or small cities are less likely to vaccinate.

Fig. 1 reports the marginal effects at means of other explanatory variables for the incentivized and stated measures of patience in the three regressions of Table 6. The predicted probability of vaccination ranges from 90.21% for respondents who placed all allocated money on the second date in the second CTB decision to 95.59% for respondents who placed no money on the second date. In regression 2 (3) of Table 6, respondents with the highest stated patience have a predicted probability of vaccination of 89.62% (88.99%) while respondents with the lowest level of patience have a predicted probability of vaccination of 95.68% (95.57%).

Appendix C presents the results of regression analyses, including interactions between time preference measures and gender, age, and income, along with associated predicted probabilities. Notably, we find no evidence of an interaction effect between time preference and age. However, we do observe that (stated) patience exerts a more pronounced influence on the vaccination decision for men than for women, leading to a decline in the predicted probability of vaccination with increasing patience among men but not among women. Concerning income, although we find a non-significant interaction effect with time preference measures (both stated and elicited), there is a significantly lower predicted probability of vaccination for respondents with low income, especially for high values of stated (≥ 5) and elicited ($\geq 60\%$ of money allocated to the second date) time preferences.

We also checked whether time preferences had a non-linear impact on COVID-19 vaccination. Splitting the sample into 4 classes, we found that respondents categorized as the most impatient were more likely to vaccinate than very patient respondents; while no significant difference in vaccination rates was discerned between very patient; rather patient;

[5] About a fifth of our sample displays future rather than present-bias, which might appear surprising. However, previous meta-analytical evidence on CTB protocols have shown that, while people are on average present-biased, there is a large heterogeneity across studies. Indeed, Imai et al. (2021) found that only 77% of present-bias parameters estimated in previous literature were below 1 (indicating present-bias) and that estimates above 1 (which indicate future-bias) were not uncommon (see for example Andreoni and Sprenger, 2012; Brocas et al., 2018; or Aycinena and Rentschler, 2018). For CTB protocols using monetary rewards, as in our study, they found an average value of the present-bias estimate of 0.98 which was not significantly different from one. Thus, on average, they do not observe statistically significant present bias which is consistent with the distribution of our sample on the time consistency categorization.

Table 6
Regression results for COVID-19 vaccination in the full sample.

	COVID-19 vaccination (Ref: 0 dose)								
	(1a)	(1b)	(1c)		(2a)		(3a)	(2b/3b)	(2c/3c)
Money allocated to risky asset (%)	−0.00244			**Willingness to take risk in general**	−0.170***	**Willingness to take risk in health**	−0.0937*		
	(0.00307)				(0.0470)		(0.0464)		
Money allocated to the second date (%, 2nd CTB decision)	−0.00829*	−0.00871*	−0.00715*	**General patience**	−0.0944*	**General patience**	−0.0988*	−0.0919*	−0.0935*
	(0.00392)	(0.00403)	(0.00352)		(0.0440)		(0.0428)	(0.0429)	(0.0439)
Prosociality (SVO angle)	0.00903				0.0105		0.0104		
	(0.00806)				(0.00838)		(0.00804)		
Trust score	0.0386				0.0642		0.0494		
	(0.0552)				(0.0556)		(0.0556)		
Female	−0.0122	0.00825			−0.0497		−0.0344	0.0532	
	(0.217)	(0.215)			(0.220)		(0.228)	(0.215)	
Age (Ref: 18–49 years old)									
50–64 years old	0.175	0.164			0.148		0.150	0.193	
	(0.263)	(0.263)			(0.265)		(0.267)	(0.263)	
$\geq$ 65 years old	0.805*	0.819**			0.822**		0.825*	0.921**	
	(0.318)	(0.318)			(0.318)		(0.324)	(0.318)	
Rural city or city < 10,000 inhabitants	−0.595**	−0.582**			−0.538*		−0.547*	−0.571*	
	(0.229)	(0.225)			(0.235)		(0.234)	(0.228)	
Education level (Ref: < *A*-Level)									
A-Level	−0.111	−0.0888			−0.237		−0.230	−0.233	
	(0.344)	(0.341)			(0.354)		(0.352)	(0.346)	
> *A*-Level to bachelor's degree	0.272	0.352			0.103		0.181	0.214	
	(0.329)	(0.326)			(0.335)		(0.334)	(0.329)	
Master's degree or PhD	−0.155	−0.102			−0.386		−0.319	−0.250	
	(0.339)	(0.334)			(0.345)		(0.344)	(0.339)	
Monthly income (Ref: 0€ to 2000€)									
€2001 to €4000	0.903***	0.920***			0.866***		0.823**	0.875***	
	(0.258)	(0.252)			(0.261)		(0.261)	(0.253)	
More than €4000	1.539***	1.564***			1.535***		1.404***	1.499***	
	(0.353)	(0.351)			(0.338)		(0.348)	(0.342)	
Do not know or do not wish to answer	0.0576	0.0982			0.0484		−0.00589	0.0781	
	(0.359)	(0.357)			(0.378)		(0.368)	(0.366)	
Risk for a severe COVID-19 form	0.440	0.393			0.505		0.428	0.410	
	(0.301)	(0.294)			(0.306)		(0.299)	(0.294)	
Individual at risk in the household	0.357	0.371			0.330		0.375	0.387	
	(0.313)	(0.307)			(0.314)		(0.308)	(0.310)	
Constant	1.559**	1.903***	2.699***		2.268***		1.830***	1.926***	2.759***
	(0.518)	(0.430)	(0.282)		(0.584)		(0.532)	(0.456)	(0.299)
N	1038	1038	1038		1038		1038	1038	1038
Pseudo R^2	0.095	0.091	0.006		0.116		0.101	0.090	0.008

Standard errors in parentheses;
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

and rather impatient respondents (see Table D1 in Appendix D). This suggests a non-linear shape, as if dose-response relationship was at stake.

As mentioned, the CTB task was able to detect time-inconsistent discounting. Table 7 displays the results of the stratified regression (regression 1a in Table 6) by time consistency categorization. Patience, as measured by the share of money allocated to the second date in the second CTB decision, is negatively associated with COVID-19 vaccination only for present-biased respondents.

5. Discussion

Few studies have investigated the association between validated measures of economic preferences and actual COVID-19 vaccination decisions. Based on a representative sample of the French population, this study is the first to provide data on individual preferences elicited on a series of incentivized experimental tasks (in a 'lab-in-the-field' setting) and to connect these large sets of preferences with data on COVID-19 vaccination uptake. In doing so, a negative association was established between a person's patience and their COVID-19 vaccination status, which is a novel result.

The fact that respondents exhibiting patience are less likely to be vaccinated underlines the specific context in which COVID-19 vaccination decisions were made. Indeed, the past literature suggests the opposite for common vaccinations (Chapman, 1999; Tsutsui et al., 2010): respondents who are patient discount the long-term benefits of vaccination less significantly and would be expected to be more likely to get vaccinated, compared to those who are impatient. However, the theoretical model that we offered in a preamble helps to understand why the vaccine-pass policy reversed the relationships between impatience and vaccine uptake: in the context of the COVID-19 crisis with its successive lockdowns and measures for sanitary containment, impatient respondents may perceive vaccination as the key to a more rapid return to "life as before", or at least, for a means of re-accessing without delay the activities for which a sanitary passport is required (a positive vaccination status being the simplest way to obtain a pass). Impatient respondents are therefore more eager to get vaccinated because they put more weight on immediate rewards. This is especially true among men

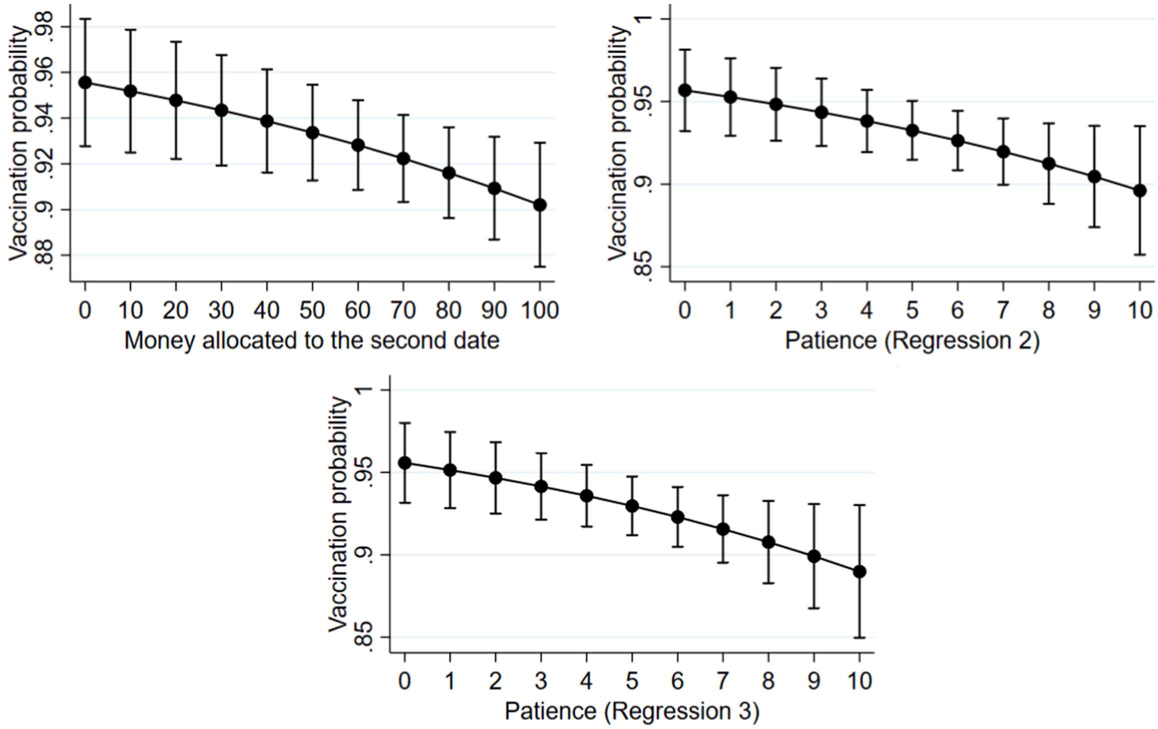

Fig. 1. Predicted vaccination probability based on time preference.

and low-income respondents in our sample.

This can also help to understand the finally good rates of vaccination obtained at the end of the first COVID-19 vaccination campaign in France. Indeed, COVID-19 vaccine hesitancy was high in the French population at the beginning of the crisis (Peretti-Watel et al., 2020); and final uptakes rates among the adult population - 90% - have been surprisingly high, at least in comparison with those expected in early 2021, in particular for a vaccine that was based on a technology, messenger-RNA, not widely known from the general public. In the case of the COVID-19, the vaccine-pass changed the deliberation on vaccine acceptance. The vaccine decision was not viewed *per se*, but in relation to the long list of sacrifices that the individuals would have to make if they remained unvaccinated, including maintaining other prophylactic behaviors (mask wearing, social distancing, regular testing) or renouncing to various social activities (going to leisure places such as bars and restaurants, attending sporting or cultural events, etc.). To sum up, vaccine uptake was in this context driven by an immediate benefit; escaping economic and social restrictions; which strongly incentivized impatient people who were *a priori* the more reluctant to get vaccinated. In other words, the vaccine-pass created a context of vaccination eagerness for impatient individuals, i.e., the wish to get vaccinated as soon as possible, which was already described for other infectious diseases like monkeypox (Gagneux-Brunon, Dauby, Launay, & Botelho-Nevers, 2022) or HPV (Chyderiotis et al., 2022).

The strength of the study is that the data collected mixes robust elicitation tasks revealing preferences of respondents and their COVID-19 vaccination status at the end of the initial campaign (in September 2021, two doses were required – yet we include respondents who received only one dose, to encompass the latecomers). Potential weaknesses in the research could be: untruthfulness on the part of respondents regarding vaccination status (although the reasons for lying would be unclear) and possible mismatch between experimental elicitations made in the monetary domain and actual preferences at stake in the health domain (Attema, Bleichrodt, L'haridon, Peretti-Watel, & Seror, 2018). However, these weaknesses - despite their potential to alter the null result obtained for risk-aversion measures - are not likely to impact the main result regarding impatience.[6] As a limitation, we acknowledge that we cannot ensure the inclusion of all necessary control variables that might influence vaccine uptake behavior in our regressions. For instance, the absence of data on potential probability distortion introduces uncertainty, as some individuals may overestimate low probabilities and, consequently, be more sensitive to vaccine side effects. To address this "omitted variables" concern, we adopted two approaches: first, we incorporated a standard set of control variables commonly employed in vaccination uptake studies; second, we conducted sensitivity analyses by testing various configurations of control variables, assessing the stability of coefficients across different model specifications.

Of interest to policy makers is that our findings suggest that impatience was a key motivational lever for COVID-19 vaccine uptake when the vaccination campaign took place in France in Spring and Summer 2021. They emphasize the potential for a public communication campaign based on time preferences to help increase vaccination coverage. It can also provide a rationale for the COVID-19 passport policy, viewed as an incentivizing strategy, which rested on increasing delays and obstacles to the return to normal life for the non-vaccinated. This incentivization dimension is unlikely to have been foreseen by the public authorities, but emerged as time went by.

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[6] We checked that the inclusion of a stated willingness to take risk in the health domain does not impact the main result of the study.

Table 7
Stratified regression analysis by time consistency categorization.

	COVID-19 vaccination (Ref: 0 dose)		
	Present-biased	Future-biased	Time consistent
Money allocated to risky asset (%)	−0.0000338	−0.00825	−0.00193
	(0.00813)	(0.00785)	(0.00367)
Money allocated to the second date	−0.0312*	−0.0182	−0.00319
(%, 2nd CTB decision)	(0.0124)	(0.0126)	(0.00474)
Prosociality (SVO angle)	0.0220	−0.00629	0.0102
	(0.0201)	(0.0231)	(0.00997)
Trust score	−0.00555	0.0742	0.0164
	(0.115)	(0.185)	(0.0723)
Female	−0.484	1.084	−0.174
	(0.528)	(0.586)	(0.293)
Age (Ref: 18–49 years old)			
50–64 years old	−0.0668	0.276	0.291
	(0.653)	(0.675)	(0.334)
≥ 65 years old	0.144	2.479*	0.916*
	(0.608)	(1.101)	(0.447)
Rural city or city < 10,000 inhabitants	−0.416	−1.102	−0.671*
	(0.511)	(0.629)	(0.296)
Education level (Ref: < *A*-Level)			
A-Level	0.557	−1.493	0.0322
	(0.697)	(0.938)	(0.486)
> *A*-Level to bachelor's degree	1.373	−1.010	0.292
	(0.712)	(0.852)	(0.426)
Master's degree or PhD	−0.264	−1.568	−0.00680
	(0.696)	(0.972)	(0.424)
Monthly income (Ref: 0€ to 2000€)			
€2001 to €4000	1.996**	0.393	0.792*
	(0.638)	(0.680)	(0.342)
More than €4000	2.775*	1.313	1.418***
	(1.080)	(1.086)	(0.414)
Do not know or do not wish to answer	0.682	0.0513	0.0962
	(0.903)	(0.960)	(0.465)
Risk for a severe COVID-19 form	0.947	0.259	0.249
	(0.834)	(0.673)	(0.376)
Individual at risk in the household	0.498	−0.454	0.433
	(0.841)	(0.762)	(0.419)
Constant	2.536*	3.636*	1.186
	(0.991)	(1.808)	(0.705)
N	244	218	576
Pseudo R^2	0.204	0.188	0.087

Standard errors in parentheses;
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Ethics approval statement

The Aix-Marseille University Ethics Committee reviewed the study (June 2021, N° 2021-06-03-04).

Data availability

The data underlying this article will be shared on reasonable request to the authors.

CRediT authorship contribution statement

Marlène Guillon: Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Phu Nguyen-Van:** Formal analysis, Validation, Writing – original draft, Writing – review & editing. **Bruno Ventelou:** Conceptualization, Formal analysis, Funding acquisition, Project administration, Validation, Writing – original draft, Writing – review & editing. **Marc Willinger:** Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.socec.2024.102190.

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