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The role of impulsivity and delay discounting in student compliance with COVID-19 protective measures

Annelot Wismans [a,b,*], Srebrenka Letina [c,m], Karl Wennberg [d,m], Roy Thurik [a,b,e], Rui Baptista [f], Andrew Burke [g], Marcus Dejardin [h,i], Frank Janssen [h], Enrico Santarelli [j], Olivier Torrès [e,k], Ingmar Franken [b,l]

[a] Erasmus School of Economics, Erasmus University Rotterdam, the Netherlands
[b] The Erasmus University Rotterdam, Institute for Behavior and Biology (EURIBEB), the Netherlands
[c] University of Glasgow, United Kingdom
[d] Department of Management and Organization, Stockholm School of Economics, Sweden
[e] Montpellier Business School, France
[f] Instituto Superior Técnico, University of Lisbon, Portugal
[g] Trinity Business School, Trinity College Dublin, Ireland
[h] Université catholique de Louvain, Belgium
[i] Université de Namur, Belgium
[j] Department of Economics, University of Bologna, Italy
[k] University of Montpellier, France
[l] Erasmus School of Social and Behavioural Sciences, Erasmus University Rotterdam, the Netherlands
[m] Institute for Analytical Sociology (IAS), Linköping University, Sweden

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ABSTRACT

During the 2020 COVID-19 pandemic, governments set recommendations and restrictions that have given rise to new situations that require residents to deliberate and respond nonautomatically. For highly impulsive individuals, dealing with these situations may be harder, as they tend to deliberate less about the consequences of their behaviors. In this study, we investigate the relationship between impulsivity and delay discounting on the one hand and compliance with COVID-19 restrictions on the other hand. We distinguish between compliance with social distancing measures and compliance with hygiene measures. Regression analyses of an international sample of 6759 students from seven European countries reveal that the self-reported personality construct of impulsivity is negatively related to both types of compliance behavior. However, and unexpectedly, we also find a weak positive association between the discount rate—as measured by a behavioral task—and compliance. Our study highlights the importance of individual differences in impulsivity in regard to compliance with public health measures during a pandemic.

1. Introduction

During the 2020 COVID-19 pandemic, governments have imposed measures to protect public health[1] that require individuals to engage in behavior changes, e.g., maintaining a physical distance between oneself and others and limiting the number of one's social contacts (e.g., Sebhatu et al., 2020; Wismans et al., 2020). These new situations have required individuals to engage in deliberation and to respond nonautomatically, for example, when making decisions between the suddenly risky action of seeing friends or staying at home. While meeting friends leads to the immediate benefit of a social reward, staying at home leads to the long-term benefit of staying healthy and contributing to 'flattening the curve'. For impulsive individuals, making health-conscious decisions could be harder, as they tend to respond automatically and deliberate less about behavioral consequences than most people of equal ability (Dickman, 1990; Dalley, Everitt, & Robbins,

* Corresponding author at: Erasmus School of Economics, Erasmus University Rotterdam, PO Box 1738, 3000 DR Rotterdam, the Netherlands.
E-mail address: wismans@ese.eur.nl (A. Wismans).

[1] Throughout the paper we use the term 'measures' to describe the set of restrictions and recommendations imposed by governments during the 2020 COVID-19 pandemic.

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2011). Moreover, highly impulsive individuals are more easily distracted (Stanford et al., 2009) and so are more likely to forget to wash their hands or to avoid touching their face, making it more difficult for them to comply with the required changes to hygiene behaviors.

Impulsivity covers a wide range of behaviors and actions that lack forethought, are overly risky or prematurely expressed, and often lead to unwanted outcomes (Evenden, 1999). Impulsivity is seen as a complex concept that is both part of standard individual differences in personality, as well as more dysfunctional and pathological behaviors (Dickman, 1990). Impulsive behaviors may at times be adaptive for individuals as well as groups (Williams & Taylor, 2006). However, impulsivity is also related to risky behaviors and negative outcomes such as high-risk sexual behavior, obesity, substance abuse and gambling (Butler & Montgomery, 2004; Slutske et al., 2005). A concept related to impulsivity is 'delay discounting', which relates to preferences for immediately available rewards over larger rewards that are available later (Ainslie, 1975). Delay discounting is often measured using behavioral tasks (Reynolds, Ortengren, Richards, & de Wit, 2006) that capture individuals' tendencies to devalue temporally distant rewards even though they are more valuable than the immediately available benefits (Madden & Bickel, 2010). The personality construct of impulsivity is often gauged using self-report measures such as the Barratt Impulsiveness Scale (BIS) (Barratt, 1959; Patton et al., 1995). Both delay discounting and impulsivity are associated with a lack of foresight and with ignoring the future consequences of behavior, and as such, delay discounting is often regarded as an aspect of impulsivity. However, prior studies have found little overlap between self-reported impulsivity and behavioral tasks that assess delay discounting (Reynolds et al., 2006; Bernoster et al., 2019). This suggests that delay discounting represents an associated but distinct aspect of impulsivity.

During widespread pandemics such as the COVID-19 pandemic, a lack of deliberation and a tendency toward risky behaviors could lead to impulsive persons being more likely to violate governmental measures. The same could be true for people with higher discount rates who place a higher value on immediately available rewards. For example, such individuals may place a higher value on socialization obtained through noncompliance than on the potential long-term reward of fewer restrictions obtained through collective compliance. Consequently, more impulsive individuals and those with higher discount rates could be more likely to violate public health measures and therefore be more prone to becoming infected with and spreading the COVID-19 virus.

Given the novelty of the situation, there is hardly any evidence on the relationship between impulsivity and compliance with COVID-19 measures. Three studies (two of which non peer reviewed) have been conducted studying the link between self-reported impulsivity and compliance, all showing a strong negative association (Kuiper et al., 2020; Van Rooij et al., 2020; Alper et al., 2020). While Kuiper et al. (2020) and Van Rooij et al. (2020) focused solely on social distancing and stay-at-home measures, Alper et al. (2020) focused on a composite measure of several types of restrictions. In all three studies, impulsivity was not the main variable of interest, and the results were based on relatively small samples from a single country.

Several studies indirectly support our expectations of a negative relationship between impulsivity and compliance. Studies have shown that psychopathy and ADHD, both associated with high levels of impulsivity, are related to lower compliance with the measures and with risk of COVID-19 infection. For example, Merzon et al. (2020) found that untreated ADHD is a risk factor for COVID-19 infection, which could be driven by a lower ability to comply with COVID-19 measures due to the characteristics associated with ADHD. Other studies have linked higher levels of psychopathy to low compliance with the measures and even an intent to knowingly expose others to risk (Blagov, 2020; Nowak et al., 2020; O'Connell et al., 2021). Finally, Miguel et al. (2020) showed that people who followed all types of measures exhibited fewer traits related to antisocial personality disorder than people who followed none of the measures.

Delay discounting has been used to explain many of the contradictory choices that people make. Specifically, time preferences play a role in choices that involve behaviors with delayed (long-term) benefits and immediate (short-term) costs, for example, the choice to resist the instant gratification of smoking another cigarette in exchange for the long-term benefit of staying healthy. Higher discount rates have been used to explain a range of maladaptive behaviors, such as substance use, overeating, problem gambling and low treatment adherence (Bickel & Marsch, 2001; Stoianova et al., 2018; Weller et al., 2008).

These choice dilemmas are closely related to the situation surrounding the 2020 COVID-19 pandemic. Not complying with the COVID-19 measures provides short-term benefits (such as being able to go outside and seeing friends) and eliminates the short-term costs of compliance but leads to adverse long-term consequences (such as becoming infected and spreading the virus) and eliminates long-term rewards (such as staying healthy and contributing to flattening the curve). Nese et al. (2020)—using hypothetical compliance decisions over time—showed that compliance follows a hyperbolic-like curve, decreasing over time, with steeper discounting rates when the stated likelihood of contracting COVID-19 is lower. Relatedly, Van Hulsen et al. (2020) showed that consideration of future consequences is positively related to compliance with measures related to COVID-19 in the Netherlands.

1.1. The current study

Our study uses a large international sample of university students. As the health consequences of COVID-19 infections for younger individuals are in general much less severe (Wu & McGoogan, 2020), evidence on students' compliance behavior is important. Young people may need to think more about the consequences of their behavior for the older people surrounding them than about the consequences for themselves. The increase in infections traced back to younger individuals at the start of the second wave across Europe and in the United States (The Economist, 2020) also makes students a relevant demographic group to study.

Generally, the recommendations and restrictions set by governments can be divided into measures related to *hygiene* and measures related to *social distancing*. While previous studies on compliance tend to construct composite measures of these behaviors, recent papers have shown that when studying compliance with public health restrictions surrounding pandemics, it is important to distinguish between compliance with measures related to social distancing and hygiene. This is because the level and antecedents of compliance with social distancing measures and compliance with hygiene measures are found to be different (Bish & Michie, 2010; Wismans et al., 2020).

In this study, we therefore investigated the link between self-reported impulsivity and delay discounting on the one hand and compliance with social distancing and hygiene measures on the other among university students. Based on the literature presented above, we formulated the following four hypotheses concerning compliance with governmental measures during the first wave of the 2020 COVID-19 pandemic:

H1a. Self-reported impulsivity is negatively related to compliance with social distancing measures.

H1b. Self-reported impulsivity is negatively related to compliance with hygiene measures.

H2a. The temporal discount rate is negatively related to compliance with social distancing measures.

H2b. The temporal discount rate is negatively related to compliance hygiene measures.

Table 1
Descriptive statistics, Cronbach's alphas and correlations of total sample (N = 6759).

	M	SD	α	1	2	3	4	5	6
1. Social distancing	4.23	0.66	0.71	–					
2. Hygiene	3.94	0.72	0.52	0.18	–				
3. BIS-Brief Impulsivity	1.99	0.46	0.74	−0.12	−0.15	–			
4. Discount rate - ln(*k*)	−5.82	1.85	–	0.07	0.05	−0.02	–		
5. Age	22.76	5.84	–	0.12	0.11	−0.12	0.03	–	
6. Gender (1 = female)	0.62	0.49	–	0.09	0.12	0.01	0.07	−0.03	–
7. Social norm	5.56	1.10	–	0.23	0.12	−0.10	0.04	0.04	0.03

Note: correlations in excess of |0.02| are statistically significant at the 5% level.

2. Methods

2.1. Participants

In the early phase of the COVID-19 pandemic (week 17–19 2020), an online questionnaire was distributed among university students in 10 countries. The current study uses data on students in 7 of these countries[2]: Belgium, France, Ireland, Italy, the Netherlands, Sweden and Portugal. Our sample consisted of 6759 graduate and undergraduate students. The survey was approved by the Internal Review Board of Erasmus University Rotterdam in advance and was shared with the target group for 13 consecutive days using the online survey software Qualtrics. Students could choose to complete the survey in English, Dutch or French, and translations were made by two native speakers per language. All students signed an informed consent form at the start of the survey.

On average, respondents were 22.76 years old (standard deviation, SD, 5.84). A total of 61.7% were female, in line with the gender distribution at these universities and at nontechnical European universities in general. Information on country samples is presented in Appendix A (Table A.1).

2.2. Measures

2.2.1. Compliance with social distancing and hygiene measures

Compliance behavior was measured using 9 items. Prior research using principal component analysis has shown that these items are best divided into two types of behavior: social distancing compliance and hygiene compliance (Wismans et al., 2020). The social distancing measure consisted of 6 items, and the hygiene measure consisted of 3 items. Students had to indicate to what extent they (dis)agreed with the statements on a scale of 1 (completely disagree) to 5 (completely agree). Examples of social distancing statements are '*I only went outside if it was strictly necessary*' and '*When outside I kept the advised distance between me and others*'. The three hygiene statements are '*I coughed and sneezed into my elbow and/or used a handkerchief*', '*I washed my hands more often and longer*' and '*I avoided touching my face*'. The reliability of the social distancing measure was good (α = 0.71), although the reliability of the hygiene measure was relatively low (α = 0.52), likely because it consisted of only three items. See Wismans et al. (2020) for further validation of these two constructs.

2.2.2. Barratt Impulsiveness Scale-Brief (BIS-Brief)

Impulsivity was assessed using the BIS-Brief by Steinberg et al. (2013), a shorter unidimensional version of the BIS-11 (Patton et al., 1995) consisting of 8 items. Steinberg et al. (2013) demonstrated the internal consistency, construct validity and concurrent validity of the 8-item impulsivity measure and concluded that the BIS-Brief reduces the burden on participants without loss of information. Answers were given on a 4-point scale ranging from Rarely/Never (1) to Almost Always/Always (4). Half of the items were reverse coded. Items from validated translations of the BIS-11 were used for the French (Baylé et al., 2000) and Dutch (Lijffijt & Barratt, 2005) versions of the survey. The reliability of the instrument in our sample was good (α = 0.74).

2.2.3. 5-Trial Adjusting Delay Discounting Task

o measure the discount rate in a fast and accurate manner, we used the 5-trial adjusting delay discounting task (Koffarnus & Bickel, 2014). The discount rate obtained using this task correlates to that obtained from lengthier tasks (Koffarnus & Bickel, 2014) and was validated by Cox and Dallery (2016). In this task, students make five consecutive hypothetical choices between receiving €1000 after a delay and €500 now. The task starts with a delay of 3 weeks, and the delay is increased or decreased based on previous choices made until reaching the 'indifference delay', which is used to calculate the discount rate (*k*). We use a natural log transformation of the discount rate (Koffarnus & Bickel, 2014; Yoon & Higgins, 2008). For more information on the mathematical procedure, see Appendix B (or see Koffarnus & Bickel, 2014).

2.2.4. Control variables

We controlled for students' age and gender, as these relate to both impulsivity and compliance with protective health behaviors (Bish & Michie, 2010; Chamorro et al., 2012). Age was measured as a continuous variable and gender as a binary variable (0: male, 1: female). We also controlled for the degree to which students reported that friends and family members followed the public health measures. Social norms are powerful shapers of behavior (Cialdini & Goldstein, 2004), and studies have shown that they play an important role in explaining compliance with COVID-19 measures (Van Rooij et al., 2020). The social norm was measured with the question '*To what extent do your family and friends strictly follow the measures related to the coronavirus?*' with a 7-point Likert scale (1 = 'They do not follow the measures at all'–7 = 'They strictly follow all measures'). Missing data were below 1.5% for all major variables included in the below models.[3]

3. Results

We present descriptive statistics, Cronbach's alpha values and correlations in Table 1. Information on the country samples is presented in Appendix B (Table B.1). In general, student compliance with COVID-19 measures in our sample was high, especially for social distancing behaviors. Self-reported impulsivity as measured by the BIS-Brief correlated negatively with both social distancing and hygiene compliance, whereas the discount rate correlated positively with social distancing and hygiene compliance. Impulsivity and the discount rate were not

[2] We do not use the data from students in Spain, Colombia, or India due to (i) a translation mistake in the Spanish version (Spain and Colombia) of the delay discounting task and (ii) the large difference in discount rates between Indian and European students (likely due to differences in currency and the perceived value of money).

[3] Regressions on 50 imputed datasets based on all the main variables in the final model were conducted. The average values of the pooled estimates and regression coefficients were almost identical to the results from the nonimputed dataset.

Table 2
Results regression analyses with social distancing as dependent variable.

	Model 1 Social Distancing		Model 2 Social Distancing		Model 3 Social Distancing	
	B (*SE*)	*p*	*B* (*SE*)	*p*	*B* (*SE*)	*p*
BIS-Brief Impulsivity	−0.13 (0.02)	<.001	−0.12 (0.02)	<.001	−0.10 (0.02)	<.001
Discount rate - ln(*k*)	0.05 (0.004)	<.001	0.04 (0.004)	<.001	0.03 (0.004)	.004
Age			0.09 (0.00)	<.001	0.08 (0.001)	<.001
Gender			0.09 (0.02)	<.001	0.09 (0.02)	<.001
Social norm					0.19 (0.01)	<.001
N	6686		6598		6593	
Adjusted R2	0.15		0.16		0.19	

Note: *B* is standardized beta. All models include country dummies, coefficients are not presented, Dutch students serve as a reference group.

Table 3
Results regression analyses with hygiene as dependent variable.

	Model 1 Hygiene		Model 2 Hygiene		Model 3 Hygiene	
	B (*SE*)	*p*	*B* (*SE*)	*p*	*B* (*SE*)	*p*
BIS-Brief Impulsivity	−0.15 (0.02)	<.001	−0.13 (0.02)	<.001	−0.12 (0.02)	<.001
Discount rate - ln(*k*)	0.05 (0.005)	<.001	0.03 (0.005)	.004	0.03 (0.005)	.008
Age			0.11 (0.002)	<.001	0.11 (0.002)	<.001
Gender			0.15 (0.02)	<.001	0.14 (0.02)	<.001
Social norm					0.09 (0.01)	<.001
N	6688		6601		6595	
Adjusted R2	0.05		0.08		0.09	

Note: *B* is standardized beta. All models include country dummies, coefficients are not presented, Dutch students serve as a reference group.

statistically related, in line with prior studies (Reynolds et al., 2006; McLeish & Oxoby, 2007).

To test our hypotheses, we conducted regression analyses with social distancing compliance (Table 2) and hygiene compliance as the dependent variables (Table 3). All models controlled for country differences using dummy variables (omitted from the regression tables). We first estimated the models without control variables (model 1), then included age and gender (model 2), and finally included social norms (model 3). We based our conclusions on the final model (model 3, Tables 2 and 3).

Confirming our first two hypotheses 1a and 1b, we found that self-reported impulsivity is negatively related to both social distancing compliance ($B = -0.10$, $p < .001$) and hygiene compliance ($B = -0.12$, $p < .001$). However, in contrast to hypotheses 2a and 2b, the discount rate is positively—though weakly—related to both social distancing compliance ($B = 0.03$, $p = .004$) and hygiene compliance ($B = 0.03$, $p = .008$).

3.1. Robustness and sensitivity checks

To further investigate the results, robustness and sensitivity checks were conducted which are discussed and presented in the Appendix. We conducted subsample analyses by country (Appendix C), gender (Appendix D), nationality (international versus domestic students) (Appendix E), and age groups (Appendix F). Moreover, we tested whether the relationships hold when using follow-up data (Appendix G), when transforming the skewed dependent variables (Appendix H) and when using different – but related – dependent variables (Appendix I). Overall, the results show that the impulsivity compliance is robust across analyses. Moreover, we generally confirm the positive relationship between discount rate and compliance with COVID-19 measures in most analyses, although in some subgroup analyses (with smaller *N*) the result is not present or statistically significant at conventional *p*-value levels.

4. Discussion

In our international sample of university students, we found that the self-reported personality construct impulsivity is negatively related to compliance with both social distancing and hygiene measures. Moreover, we found a positive but weak association between the discount rate and compliance with both types of COVID-19 measures.

4.1. Self-reported impulsivity and compliance

The negative association between self-reported impulsivity and both compliance behaviors confirm our hypotheses (H1a and H1b): more impulsive students are more likely to show decreased compliance with social distancing and hygiene measures (Alper et al., 2020; Kuiper et al., 2020; Van Rooij et al., 2020). Our paper provides novel empirical insights by showing that self-reported impulsivity is negatively related not only to compliance with social distancing and stay-at-home measures but also to compliance with hygiene behaviors. We found trait impulsivity to be related to lower compliance, extending studies that have related ADHD and psychopathy to COVID-19 infection (Merzon et al., 2020) and to decreased compliance with COVID-19 measures (Blagov, 2020; Nowak et al., 2020; O'Connell et al., 2021). Multiple sensitivity tests indicated that the relationship between impulsivity and compliance was robust. Follow-up data, collected nine months after the main data collection, also showed that impulsivity was not only related to compliance in the initial phase of the pandemic but was also negatively associated with prolonged compliance.

4.2. Delay discounting and compliance

Contrary to our hypotheses (H2a and H2b), we found a positive—albeit small—link between the discount rate and social distancing and hygiene compliance, indicating that students with a higher discount rate (i.e., more impatient, and more strongly present-biased students) were more likely to comply with both types of COVID-19 public health measures. This surprising result motivated us to analyze the robustness of the relationship using sensitivity tests. While the association was not always statistically significant in the subgroup analyses, it was predominantly positive and never statistically significant in the theoretically expected direction. Our relatively large sample provided statistical power to detect this small but robust deviation from prior theory. Below, we discuss the possible theoretical mechanisms and methodological issues that may underlie this finding. These explanations are not mutually exclusive.

4.2.1. COVID-19 induced stress

Previous literature showed that higher stress levels are related to greater delay discounting (Malesza, 2019). It is thus possible that stress induced by the COVID-19 crisis affected the relationship found, causing both greater delay discounting and higher compliance with COVID-19 measures. The choice for a monetary discount rate may have strengthened this effect, as from the early days of the COVID-19 crisis, it was

recognized that the pandemic was likely to cause a financial crisis for many people. Hence, increased COVID-19 related stress may have affected both compliance and negative expectations related to COVID-19-induced financial insecurity. Consequently, students with more worries could be more inclined to forsake a larger financial gain in the future for a smaller gain in the present.[4]

4.2.2. Long-term versus short-term benefits

Given the uniqueness of the COVID-19 pandemic, it was surrounded by a lot of uncertainty regarding its duration. It is possible that students did not perceive compliance to have benefits only in the long run but rather on a more short-term. As governments put emphasis on the short-term benefits of compliance in their communication (e.g., 'The more we comply with the measures, the sooner we will be out of the pandemic') students could have had the idea that the objectives would be reached soon. If the benefits of compliance were perceived to occur rather sooner than later, this would mean that they were to be discounted less.[5]

4.2.3. Statistical artifact(s)

While the analyses conducted on the subgroups within our sample did not provide a strong indication of the existence of opposite relationships within groups, something which is known as Simpson's paradox (Simpson, 1951), there could be other unobserved factors that affect the relationship between compliance and discount rate in different subgroups in our data. There could for example be an unmeasured country-level variable related to public health, standards of living or culture that moderates the relationship between the discount rate and compliance (Strimling et al., 2018). Finally, since our sample was not random or representative, but relied on a voluntary participation, the existence of a (self) selection in respect to one or more variables is possible, which in turn could have distorted observed associations (sometimes referred as collider bias, for more details see Griffith et al., 2020).

4.3. Limitations and future research

While this study is, to the best of our knowledge, the first to study the role of impulsivity and delay discounting in compliance with COVID-19 measures in a large sample of students, it has limitations. The data were collected using an online survey with self-reported measures, which elicits social desirability bias among respondents. While anonymity was emphasized and the data were collected in an online environment, students could have overreported their compliance with public health measures. Finally, the task that we used to assess the discount rate differs from the decision to comply with COVID-19 measures in three ways. First, we used a money-related instead of a health-related discounting task (Bleichrodt et al., 2016). This may be problematic as discount rates for money and health have not always been found to be universal (Attema, 2012). As compliance could be seen as a preventive health-behavior, a health-related discount rate could have been better at describing time preferences related to compliance. Second, the discount rate task assessed decisions in the individual domain, while the decision to comply with COVID-19-related measures entail trade-offs between an individual's own benefits and the societal benefits, a classical collective action dilemma. Studies show that dilemmas containing a social element decrease individuals' discount rates (Bickel et al., 2012; Charlton et al., 2013). Third, studies have shown an asymmetry in discount rates between gains and losses (Khwaja et al., 2007). In our study, we assessed discounting in the gains domain while the trade-off surrounding compliance involves potential losses. Future research could shed light on this issue by using tasks that involve domains and contexts more similar to the pandemic situation, such as health-related delay discounting tasks (Bleichrodt et al., 2016) or tasks involving a social element (Bickel et al., 2012; Charlton et al., 2013).

4.4. Conclusion

In conclusion, we found a consistent negative link between the personality trait of impulsivity and compliance with COVID-19 measures. Contrary to our hypotheses, we also found a positive but weak link between the discount rate and compliance, which warrants further research. These opposing results underline the fact that self-reported impulsivity and delay discounting are distinct concepts and should not be used interchangeably. Policy makers could take these findings into account to communicate messages in a more tailored and targeted manner. As more impulsive individuals rarely engage in extensive forethought, emphasizing the consequences of noncompliance or facilitating alternative outlets for impulses (e.g., physical activity) may be warranted to decrease the increased risk of high-impulsivity individuals to engage in risky behavior during widespread pandemics.

CRediT authorship contribution statement

Annelot Wismans: Conceptualization, Investigation, Formal analysis, Writing – original draft, Writing – review & editing, Project administration. **Srebrenka Letina:** Conceptualization, Investigation, Formal analysis, Writing – original draft, Writing – review & editing. **Karl Wennberg:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **Roy Thurik:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **Rui Baptista:** Conceptualization, Investigation, Writing – review & editing. **Andrew Burke:** Conceptualization, Investigation, Writing – review & editing. **Marcus Dejardin:** Conceptualization, Investigation, Writing – review & editing. **Frank Janssen:** Conceptualization, Investigation, Writing – review & editing. **Enrico Santarelli:** Conceptualization, Investigation, Writing – review & editing. **Olivier Torrès:** Conceptualization, Investigation, Writing – review & editing. **Ingmar Franken:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing.

Declaration of competing interest

None.

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[4] In unreported regression models, we included a control variable capturing 'How did/does the current coronavirus crisis affect your financial security?' (Likert scale, 1–5), which was negatively correlated to the discount rate (−0.12). However, all results remained almost identical when controlling for changes in financial security.

[5] This explanation is not in line with the positive link found between the discount rate and compliance measured during a later phase of the pandemic (December 2020) in our follow-up dataset (Appendix G). At that moment, the pandemic had continued over a prolonged period, hence students may have become aware that the benefits of compliance would not be reached before long.

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No funding was received for this study.

Appendix A. Information on country samples

Table A.1
Descriptive statistics country samples.

	Total (N = 6759)		NL (N = 1090)		BE (N = 3556)		PRT (N = 1275)		FR (N = 209)		SWE (N = 247)		IT (N = 193)		IRE (N = 100)	
	M/%	*SD*	*M*/%	*SD*	*M*/%	*SD*	*M*/%	*SD*	*M*/%	*SD*	*M*/%	*SD*	*M*/%	*SD*	*M*/%	*SD*
Social distancing	4.23	0.66	3.80	0.69	4.31	0.61	4.44	0.57	4.27	0.69	3.65	0.72	4.50	0.51	4.33	0.65
Hygiene	3.94	0.72	4.00	0.66	3.84	0.74	4.10	0.65	4.09	0.69	4.15	0.59	3.87	0.78	4.10	0.56
BIS-Brief Impulsivity	1.99	0.46	1.95	0.46	2.02	0.45	1.94	0.47	2.05	0.45	1.96	0.43	1.85	0.39	2.02	0.48
Discount rate - ln(k)	−5.82	1.85	−6.03	1.56	−5.89	1.90	−5.64	1.88	−4.96	1.76	−5.97	1.72	−5.27	1.94	−5.41	1.96
Age	22.76	5.84	20.76	2.81	23.24	6.51	22.79	5.83	20.56	2.16	25.73	5.77	22.62	2.69	24.38	7.03
Gender - Male (%)	38.3		42.46		31.92		52.72		28.29		42.68		46.84		36.00	
Gender - Female (%)	61.7		57.54		68.08		47.28		71.71		57.32		53.16		64.00	
Social norm	5.56	1.10	5.46	1.11	5.54	1.09	5.68	1.05	5.86	1.14	5.17	1.20	5.92	1.05	5.85	1.02

Appendix B. 5-Trial Adjusting Delay Discounting Task

To measure the discount rate, we used the 5-trial adjusting delay discounting task (Koffarnus & Bickel, 2014). As stated, in this task, students make five consecutive hypothetical choices between receiving €1000 after a delay and €500 now. The task starts with a delay of 3 weeks, and the delay is increased or decreased based on previous choices made until reaching the 'indifference delay', which is used to calculate the discount rate (k). At this indifference delay, the subjective value of both rewards is approximately equal. This is used as a measure of the 'effective delay 50' (ED_{50}). At this point, the larger reward has lost half of its subjective value (Koffarnus & Bickel, 2014). To derive estimates of the discount rate, a hyperbolic discounting model is used (Mazur, 1987):

$$V = \frac{A}{(1 + kD)}$$

V is the current value of the delayed reward (discounted value), A is the reward amount, D is the delay, and k is a parameter that reflects the discount rate. Higher values of k reflect a faster devaluation of the delayed reward and thus greater impulsivity.

ED_{50} is thus the delay (D) at which the current value (V) is half of its nominal amount (A). The indifference point (ED_{50}) that is elicited by the task is used to estimate k by taking its inverse ($1/ED_{50}$). We use a natural log transformation of the discount rate (Koffarnus & Bickel, 2014; Yoon & Higgins, 2008).

Appendix C. Regression analyses on country samples

We conducted the same regression analyses as in Tables 2 and 3 on the seven country subsamples. The results are detailed in Tables C.1 to C.7 below and show that the results obtained with the country subsamples are overall in line with the main results. Due to the smaller sample sizes, only some relationships exhibited p-values below .05.

The association between impulsivity and social distancing compliance was negative in all country subsamples, with p-values below .05 in four out of the seven samples, and most pronounced in the French sample ($B = -0.28$, SE = 0.10, $p < .001$). The impulsivity-hygiene compliance relationship was likewise negative in all country samples, with p-values below .05 in four out of the seven country subsamples. These results underline the robustness of the relationship between impulsivity and both social distancing and hygiene compliance.

With respect to the discount rate, we found a positive relationship between the discount rate and social distancing compliance ($p < .05$) in four out of the seven country subsamples. The range of the effect sizes was broad and much stronger in the Swedish ($B = 0.19$, SE = 0.03, $p < .01$) and Irish subsamples ($B = 0.21$, SE = 0.03, $p = .04$) than in the overall sample or in the other subsamples. The direction of the coefficient in two of the subsamples was negative but small ($p > .10$). The relationship between the discount rate and hygiene compliance was less pronounced in the country subsamples than in the overall sample, with only the Belgian subsample exhibiting a p-value below .05 ($B = 0.04$, SE = 0.01, $p = .03$). This indicates that the relationship between the discount rate and compliance with COVID-19 measures is overall much weaker than the relationship between impulsivity and compliance and that it is also sensitive to sample size.

Table C.1
Regression analyses – Sample the Netherlands.

	Social Distancing		Hygiene	
	B (*SE*)	*p*	*B* (*SE*)	*p*
BIS-Brief Impulsivity	−0.12 (0.04)	<.001	−0.03 (0.04)	.40
Discount rate - ln(k)	0.09 (0.01)	.002	0.04 (0.01)	.19
Age	0.06 (0.01)	.06	0.04 (0.01)	.24
Gender	0.16 (0.04)	<.001	0.17 (0.04)	<.001
Social norm	0.27 (0.02)	<.001	0.14 (0.02)	<.001
N	1067		1069	
R^2	0.14		0.05	

Note: *B* is standardized beta.

Table C.2
Regression analyses - Sample Belgium.

	Social Distancing		Hygiene	
	B (*SE*)	*p*	*B* (*SE*)	*p*
BIS-Brief Impulsivity	−0.10 (0.02)	<.001	−0.16 (0.03)	<.001
Discount rate - ln(*k*)	0.03 (0.01)	.04	0.04 (0.01)	.03
Age	0.11 (0.002)	<.001	0.13 (0.002)	<.001
Gender	0.08 (0.02)	<.001	0.15 (0.03)	<.001
Social norm	0.18 (0.01)	<.001	0.10 (0.01)	<.001
N	3558		3561	
R^2	0.07		0.09	

Note: *B* is standardized beta.

Table C.3
Regression analyses - Sample Portugal.

	Social Distancing		Hygiene	
	B (*SE*)	*p*	*B* (*SE*)	*p*
BIS-Brief Impulsivity	−0.08 (0.03)	.004	−0.10 (0.04)	<.001
Discount rate - ln(*k*)	−0.04 (0.01)	.14	0.03 (0.01)	.26
Age	0.06 (0.003)	.04	0.12 (0.003)	<.001
Gender	0.07 (0.03)	.02	0.12 (0.04)	<.001
Social norm	0.20 (0.02)	<.001	0.04 (0.02)	.16
N	1235		1231	
R^2	0.06		0.04	

Note: *B* is standardized beta.

Table C.4
Regression analyses – Sample France.

	Social Distancing		Hygiene	
	B (*SE*)	*p*	*B* (*SE*)	*p*
BIS-Brief Impulsivity	−0.28 (0.10)	<.001	−0.10 (0.10)	.15
Discount rate - ln(*k*)	0.02 (0.03)	.81	0.002 (0.03)	.98
Age	0.06 (0.02)	.35	−0.17 (0.02)	.01
Gender	−0.01 (0.10)	.92	0.15 (0.10)	.03
Social norm	0.24 (0.04)	<.001	0.19 (0.04)	.01
N	204		203	
R^2	0.16		0.11	

Note: *B* is standardized beta.

Table C.5
Regression analyses – Sample Sweden.

	Social Distancing		Hygiene	
	B (*SE*)	*p*	*B* (*SE*)	*p*
BIS-Brief Impulsivity	−0.07 (0.11)	.24	−0.15 (0.09)	.02
Discount rate - ln(*k*)	0.19 (0.03)	.003	−0.02 (0.02)	.75
Age	0.16 (0.01)	.01	−0.01 (0.01)	.86
Gender	0.02 (0.09)	.80	0.21 (0.08)	<.001
Social norm	0.11 (0.04)	.09	0.09 (0.03)	.16
N	243		244	
R^2	0.09		0.08	

Note: *B* is standardized beta.

Table C.6
Regression analyses – Sample Italy.

	Social Distancing		Hygiene	
	B (*SE*)	*p*	*B* (*SE*)	*p*
BIS-Brief Impulsivity	−0.05 (0.09)	.49	−0.10 (0.14)	.18
Discount rate - ln(*k*)	−0.04 (0.02)	.59	0.02 (0.03)	.77
Age	0.001 (0.01)	.97	0.24 (0.02)	.001
Gender	0.16 (0.08)	.03	0.12 (0.11)	.11
Social norm	0.22 (0.04)	.003	0.13 (0.05)	.09
N	188		189	
R^2	0.07		0.08	

Note: *B* is standardized beta.

Table C.7
Regression analyses – Sample Ireland.

	Social Distancing		Hygiene	
	B (*SE*)	*p*	*B* (*SE*)	*p*
BIS-Brief Impulsivity	−0.02 (0.13)	.87	−0.18 (0.12)	.08
Discount rate - ln(*k*)	0.21 (0.03)	.04	−0.05 (0.03)	.62
Age	0.20 (0.01)	.05	0.07 (0.01)	.50
Gender	0.15 (0.13)	.14	0.11 (0.12)	.27
Social norm	0.18 (0.06)	.07	0.05 (0.06)	.65
N	98		98	
R^2	0.13		0.06	

Note: *B* is standardized beta.

Appendix D. Gender

We also conducted subsample analyses for women and men (see Table D.1). For both men and women, we found a negative relationship between impulsivity and social distancing compliance, as well as hygiene compliance ($p < .05$). In the male subsample, the relationship between the discount rate and social distancing was weakly positive but with a *p*-value of 0.20, while the relationship between the discount rate and hygiene was significant ($B = 0.05$, SE = 0.01, $p = .02$). For women, we found a stable link between the discount rate and social distancing ($B = 0.04$, SE = 0.01, $p < .01$), but the link between the discount rate and hygiene had a *p*-value of 0.12. Hence, while the results of the separate analyses for men and women were consistent with the overall pattern, the discount rate was a stronger predictor of social distancing (hygiene) compliance for women (men). It is thus unlikely that gender drives the observed discount rate-compliance relationship. Introducing an interaction term ($p > .05$) between discount rate and gender to the main models in Tables 2 and 3 did not increase the variance explained by these models.

Table D.1
Regression analyses with compliance as dependent variable by gender.

Sample	Men		Women		Men		Women	
Dependent variable	Social Distancing		Social Distancing		Hygiene		Hygiene	
	B (SE)	*p*	*B* (SE)	*p*	*B* (SE)	*p*	*B* (SE)	*p*
BIS-Brief Impulsivity	−0.11 (0.03)	<.001	−0.09 (0.02)	<.001	−0.11 (0.03)	<.001	−0.13 (0.02)	<.001
Discount rate - ln(*k*)	0.02 (0.01)	.20	0.04 (0.01)	<.01	0.04 (0.01)	.02	0.02 (0.02)	.12
Age	0.08 (0.002)	<.001	0.09 (0.002)	<.001	0.11 (0.002)	<.001	0.11 (0.002)	<.001
Social norm	0.18 (0.01)	<.001	0.19 (0.01)	<.001	0.11 (0.01)	<.001	0.09 (0.01)	<.001
N	2527		4066		2528		4067	
R^2	0.22		0.17		0.09		0.07	

Note: *B* is standardized beta. All models include country dummies, coefficients are not presented, Dutch students serve as a reference group.

Appendix E. International versus national students

We can infer whether a student is a national or international student based on whether they indicated having lived in the country of their university for more than five years. The same regression analyses were conducted on the subsamples of national and international students separately (see Table E.1). In both the subsample of national students and that of international students, the impulsivity-compliance relationship was robust. The coefficient of discount rate was positive but had a *p*-value above .05 for both types of compliance in both subsamples, again indicating the sensitivity of this result to sample size.

Table E.1
Regression analyses with compliance as dependent variable by student type (international versus national).

Sample	National students		International students		National students		International students	
Dependent variable	Social Distancing		Social Distancing		Hygiene		Hygiene	
	B (SE)	*p*	*B* (SE)	*p*	*B* (SE)	*p*	*B* (SE)	*p*
BIS-Brief Impulsivity	−0.10 (0.02)	<.001	−0.11 (0.05)	.001	−0.12 (0.02)	<.001	−0.15 (0.05)	<.001
Discount rate - ln(*k*)	0.02 (0.004)	.09	0.04 (0.01)	.26	0.02 (0.01)	.15	0.03 (0.01)	.33
Age	0.08 (0.001)	<.001	0.15 (0.004)	<.001	0.11 (0.002)	<.001	0.09 (0.004)	.02
Gender	0.08 (0.02)	<.001	0.14 (0.05)	<.001	0.15 (0.02)	<.001	0.11 (0.05)	.00
Social norm	0.18 (0.01)	<.001	0.15 (0.02)	<.001	0.08 (0.01)	<.001	0.13 (0.02)	<.001
N	5722		870		5724		870	
R^2	0.22		0.12		0.09		0.06	

Note: *B* is standardized beta. All models include country dummies, coefficients are not presented, Dutch students serve as a reference group.

Appendix F. Age differences

Analyses were repeated with subsamples based on different age categories: ages 17–21, 21–26, 26–30 and over age 30 (see Tables F.1 and F.2). In all four subsamples, the impulsivity coefficient remained negative for both types of compliance behaviors ($p < .05$). In all subsamples, the discount rate coefficient remained positive for both types of compliance behaviors, but with p-values above .05 for all the smaller age groups except for the 26–30-year-old group.

Table F.1
Regression analyses with social distancing as dependent variable by age group.

Sample	Age 17–21		Age 21–26		Age 26–30		Age > 30	
Dependent variable	Social Distancing		Social Distancing		Social Distancing		Social Distancing	
	B (SE)	*p*	*B* (SE)	*p*	*B* (SE)	*p*	*B* (SE)	*p*
BIS-Brief Impulsivity	−0.10 (0.02)	<.001	−0.09 (0.03)	<.001	−0.14 (0.07)	.01	−0.10 (0.06)	.02
Discount rate - ln(*k*)	0.02 (0.01)	.12	0.03 (0.01)	.08	0.10 (0.02)	.04	0.04 (0.01)	.33
Gender	0.10 (0.02)	<.001	0.07 (0.03)	<.001	0.04 (0.06)	.38	0.13 (0.05)	.01
Social norm	0.19 (0.01)	<.001	0.19 (0.01)	<.001	0.11 (0.03)	.03	0.25 (0.02)	<.001
N	3548		2258		347		440	
R^2	0.18		0.18		0.21		0.19	

Note: *B* is standardized beta. All models include country dummies, coefficients are not presented, Dutch students serve as reference group.

Table F.2
Regression analyses with hygiene as dependent variable by age group.

Sample	Age 17–21		Age 21–26		Age 26–30		Age > 30	
Dependent variable	Hygiene		Hygiene		Hygiene		Hygiene	
	B (SE)	*p*	*B* (SE)	*p*	*B* (SE)	*p*	*B* (SE)	*p*
BIS-Brief Impulsivity	−0.11 (0.03)	<.001	−0.13 (0.03)	<.001	−0.15 (0.08)	.01	−0.19 (0.07)	<.001
Discount rate - ln(*k*)	0.02 (0.01)	.22	0.04 (0.01)	.07	0.15 (0.02)	.01	0.01 (0.01)	.77
Gender	0.15 (0.03)	<.001	0.14 (0.03)	<.001	0.11 (0.07)	.04	0.23 (0.06)	<.001
Social norm	0.09 (0.01)	<.001	0.09 (0.01)	<.001	0.16 (0.03)	.003	0.16 (0.03)	<.001
N	3549		2259		347		440	
R^2	0.09		0.07		0.08		0.12	

Note: *B* is standardized beta. All models include country dummies, coefficients are not presented, Dutch students serve as a reference group.

Appendix G. Analyses follow-up data

Students from three countries—the Netherlands, Belgium, and Portugal—were contacted again in December 2020 (T2) for a follow-up survey. We therefore also have data on compliance with social distancing and hygiene measures eight months later for 1127 students. The exact same questions were used to measure compliance in the second survey.

We used this longitudinal subsample to test whether the relationships identified remained stable over time. The same analyses as presented in Tables 2 and 3 were repeated twice. First, the exact same model with T1 compliance was estimated but using only the follow-up subsample. Second, a similar set of models was estimated but with social distancing and hygiene compliance as measured at T2 as the dependent variables. The impulsivity and discount rate measures from the first survey were used. The results are presented in Table G.1. The two regressions with T1 compliance for this subsample confirmed the negative impulsivity links, while the discount rate relationships remained positive but with p-values above .05. When estimating the models with compliance as measured at T2 as the dependent variables, the negative relationships between impulsivity and both social distancing and hygiene showed to be stable and of a similar size over time. The positive but weak relationships between the discount rate and social distancing and hygiene also remained stable over time.

Table G.1
Regression analyses with compliance at T1 (April/May 2020) and T2 (December 2020) as dependent variable - Subsample follow-up.

	Social Distancing T1		Hygiene T1		Social Distancing T2		Hygiene T2	
	B (SE)	*p*	*B* (SE)	*p*	*B* (SE)	*p*	*B* (SE)	*p*
BIS-Brief Impulsivity	−0.12 (0.04)	<.001	−0.15 (0.05)	<.001	−0.13 (0.05)	<.001	−0.14 (0.05)	<.001
Discount rate - ln(*k*)	0.02 (0.01)	.53	0.05 (0.01)	.08	0.03 (0.01)	.24	0.05 (0.01)	.06
Age	0.06 (0.003)	.03	0.16 (0.004)	<.001	0.12 (0.004)	<.001	0.10 (0.003)	<.001
Gender	0.08 (0.04)	<.001	0.15 (0.04)	<.001	0.02 (0.05)	.53	0.16 (0.04)	<.001
Social norm	0.13 (0.02)	<.001	0.06 (0.02)	.05	0.09 (0.02)	<.001	0.07 (0.02)	.01
N	1124		1127		1128		1127	
R^2	0.15		0.11		0.08		0.12	

Note: *B* is standardized beta. All models include country dummies (PRT, BE), coefficients are not presented, Dutch students serve as a reference group.

Appendix H. Transforming the dependent variables

Since compliance was scored on a five-point scale with more students indicating high compliance, the compliance measures were negatively skewed with a ceiling effect. As a further robustness check, we conducted the same analyses using transformed dependent variables. Social distancing and hygiene were both exponentially and inversely transformed to decrease skewness. Using these variables as the dependent variables with the same model specifications as in Tables 2 and 3 did not change any of the main results (see Table H.1).[6]

Table H.1
Regression analyses with transformed dependent variables.

	Social Dist. - Exponentially transformed		Social Dist. – Inverse transformed		Hygiene - Exponentially transformed		Hygiene – Inverse transformed	
	B (*SE*)	*p*	*B* (*SE*)	*p*	*B* (*SE*)	*p*	*B* (*SE*)	*p*
BIS-Brief Impulsivity	−0.10 (1.08)	<.001	−0.10 (0.01)	<.001	−0.12 (1.03)	<.001	−0.12 (0.005)	<.001
Discount rate - ln(*k*)	0.03 (0.27)	<.01	0.03 (0.001)	<.01	0.03 (0.25)	.03	0.03 (0.001)	.03
Age	0.09 (0.09)	<.001	0.09 (0.0004)	<.001	0.11 (0.08)	<.001	0.11 (0.0004)	<.001
Gender	0.08 (1.02)	<.001	0.09 (0.005)	<.001	0.13 (0.96)	<.001	0.12 (0.005)	<.001
Social norm	0.18 (0.45)	<.001	0.18 (0.002)	<.001	0.10 (0.43)	<.001	0.10 (0.002)	<.001
N	6593		6593		6595		6595	
Adjusted R2	0.17		0.17		0.08		0.08	

Note: *B* is standardized beta. All models include country dummies, coefficients are not presented, Dutch students serve as a reference group.

Appendix I. Alternative dependent variables

In our main analyses, we used composite measures of social distancing and hygiene compliance. We also examined alternative but related dependent variables: the violation of measures and general compliance (Table I.1). To assess the violation of measures, students were asked, '*Have you ever violated the measures related to the coronavirus taken by the [name country] government?*' on a scale from Never (1) to Often (5). Using the same control variables, we found that impulsivity is positively related to the violation of measures ($p < .05$), in line with the reverse coding of violation compared to compliance. However, the discount rate is not related to the violation of measures ($p > .05$). To assess general compliance, students were asked to indicate '*To what extent have you followed the measures advised by the [country name] government to prevent the spread of the coronavirus?*' on a scale ranging from 'I have not taken any measures' (1) to 'I have done everything that was possible' (7). We confirmed both results from the main analyses: impulsivity was negatively related to general compliance ($p < .05$), while the discount rate was significantly and positively related to general compliance ($p < .05$).

Table I.1
Regression analyses with alternative but comparable dependent variables.

Dependent variable	Followed measures		Violation measures	
	B (*SE*)	*p*	*B* (*SE*)	*p*
BIS-Brief Impulsivity	−0.11 (0.02)	<.001	0.10 (0.02)	<.001
Discount rate - ln(*k*)	0.03 (0.01)	.01	−0.02 (0.01)	.11
Age	0.01 (0.002)	.22	0.01 (0.002)	.51
Gender	0.12 (0.02)	<.001	−0.08 (0.02)	<.001
Social norm	0.24 (0.01)	<.001	−0.19 (0.001)	<.001
N	6613		6613	
R^2	0.14		0.13	

Note: *B* is standardized beta. All models include country dummies, coefficients are not presented, Dutch students serve as a reference group.

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