Who is Motivated to Accept a Booster and Annual Dose?

A Dimensional and Person-Centered Approach

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Abstract

Objective. The transmissibility of new COVID-19 variants and decreasing efficacy of injected vaccines led authorities to recommend a booster, and even an annual dose, to secure proper levels of immunity. Because people's willingness to accept new doses varied considerably, the present study investigates people's motivation profiles and their relationship with the willingness to get the booster and an annual dose.

Methods. Using two independent longitudinal samples of 4,596 (M_{age} = 53.6, 63.8% female) and 514 (M_{age} = 55.9, 63.7% female) vaccinated participants, we examined how people's (lack of) motivation to get vaccinated, as assessed at baseline prior to their first dose, was associated with their intention to get a booster (Sample 1) and an annual COVID vaccination dose (Sample 2) several months later (i.e., a median time lag of, respectively, 265 and 395 days; Aim 1). We also aimed to capture the motivational heterogeneity in this sample by identifying different motivational profiles (Aim 2).

Results. Across both samples and after controlling for background variables and concurrent risk perception, autonomous motivation, controlled motivation and distrust-based amotivation were associated with, respectively, higher, lower, and even lower intention to get a booster or annual dose. A two-step clustering procedure revealed five stable and meaningful motivational profiles, with profiles characterized by high autonomous motivation (i.e., Good Quality and High Quantity profiles) reporting the highest scores for vaccination intention and with profiles characterized by high distrust (i.e., Controlled/distrust-based and overall Amotivated profiles) having the lowest vaccination intention.

Conclusion. As we are heading towards a post-COVID era, these results stress the heterogeneity of the vaccinated group and the critical need to support citizens' volitional endorsement of vaccination to harvest long-term benefits with respect to COVID-19.

Keywords: motivation, vaccination intention, COVID-19, booster dose

Introduction

Vaccination against COVID-19 was effective to decrease the risk of infection (Riemersma et al., 2021) and to prevent the development of severe symptoms even several months after vaccination (Griffin et al., 2021; Patalon et al., 2021). At the same time, it became clear that vaccine efficacy decreased over time, especially as more transmissible variants emerged (e.g., Delta; Krause et al., 2021; Pouwels et al., 2021). This situation triggered scientific and public debates in the summer of 2021 about the necessity of a booster and perhaps even an annual dose for the population (Callaway, 2021; Krause et al., 2021). The discussion was spurred by studies showing that a booster dose increased people’s protection to a level obtained after the second dose, with a significant reduction in the probability to become severely ill (Andrews et al., 2022; Bar-On et al., 2021). With the new wave of COVID-19 infections in November 2021 and the subsequent emergence of the Omicron variant, countries speeded up their booster vaccination campaign, clearly encouraging the adult population to accept a booster. The first goal of the present contribution was to examine whether people’s initial motivation to get their first dose several months earlier predicted their intention to accept a booster and an annual dose months later. Second, through a person-centered approach we aimed to capture the heterogeneity within vaccinated people through the identification of motivational profiles (i.e., with distinct combinations of motivations and obstacles for vaccination commitment), which were then linked to individuals’ intention to accept a booster or an annual dose.

Booster and Annual Dose Hesitation

Although one may take for granted that the acceptance of a first dose translates into a long-term commitment to vaccines, this is not necessarily the case. Some vaccinated people later hesitated or even became reluctant to get a new shot (Pal et al., 2021), with a variety of reasons explaining lowered enthusiasm. As high expectations for lasting vaccine efficacy failed to materialize, some individuals started doubting the sustainability of the immunity conferred by the vaccine (e.g., Su et al., 2021; Sugawara et al., 2021). Vaccinated persons who had felt obliged or had been seduced into vaccination may lack the energy to persist later (Sprengholz et al., 2022) or even experience reactance towards a new dose (Brehm & Brehm, 2013). Further, the experience of side effects from previous doses (Abuhammad et al., 2022; Rzymski et al., 2021) has been shown to discourage vaccinated individuals to get booster and annual doses. The lack of trust in governmental information about the booster (Folcarelli et al. 2022), lack of trust in scientists and medical professionals (Toro-Ascuy et al., 2022) and in the pharmaceuticals industry (Al Janabi & Pino, 2021) may also explain reluctance towards a booster dose and annual dose, even among vaccinated individuals.

Furthermore, while the first doses of vaccine have contributed to a reduction in mortality and infection rates, this may ironically lead to a lower risk perception, and thus a lower motivation to receive the annual dose (Abuhammad et al., 2022; Wu et al., 2022). Also sociodemographics have been showed to play a role in individuals' intention to accept annual and booster shots as well, with young, minority members, females and those living alone or having lower income being more likely to manifest COVID-19 vaccination hesitancy (e.g., Reifferscheid et al., 2022; Rzymski et al., 2022; Zintel et al., 2022).

As a set, these findings suggest that the larger group of vaccinated people might be less homogeneous in terms of their attitude towards future booster vaccines than what is generally considered. Unfortunately, motivational factors explaining the heterogeneity in individuals' intention to accept or refuse a booster or an annual dose remain largely overlooked. Herein, we adopt a theory-grounded, motivational approach in examining which types of motivation and lack of motivation predicted citizens' intention to take up a booster or an annual dose (e.g., Schmitz et al., 2022).

The Role of Motivation

Within the framework of Self-Determination Theory (Ryan & Deci, 2017; Ryan et al., 2021), types of motivation are not created equally. Not only the amount but also and especially the type of motivation to engage in health-relevant behavior (e.g., vaccination) is considered critical (Vansteenkiste et al., 2006). In the case of *autonomous motivation,* individuals have accepted or internalized the utility and relevance of vaccination such that they willingly do so. In the case of *controlled motivation,* external pressures (e.g., avoiding social criticism) or internal pressures (e.g., guilt) guide one's intentions, with individuals feel forced or seduced to be vaccinated. This differentiated approach is equally useful when considering reasons for refusing a vaccine. *Distrust-*

based amotivation denotes a reluctance towards vaccination, either because of the perception that the vaccine is inefficient if not unsafe or because the recommending authorities are not to be trusted (Milošević Đorđević et al., 2021). Finally, *effort-based amotivation* reflects individuals' perception that vaccination is an effortful process for which they lack mental or physical resources (Legault et al., 2006; Pelletier et al., 1999).

Recent research confirmed the role of these motivational factors to predict concurrent vaccination intention (Van Oost et al., 2022), transition towards greater intended acceptance (Waterschoot et al., 2022) and eventual uptake (Schmitz et al., 2022) of first and second COVID vaccine doses. Autonomous motivation is the most robust predictor across studies, with individuals high in autonomous motivation reporting greater vaccination intentions, displaying a faster transition away from reluctance to intended acceptance, and being more likely to take the vaccine. In contrast, controlled motivation yields small and mixed effects. Although controlled motivation manifested a slight positive relation with concurrent intentions and eventual uptake in one set of studies (Schmitz et al., 2022), this finding was not replicated by Van Oost et al. (2022) and controlled motivation even prevented individuals from transitioning to greater vaccination intentions across time (Waterschoot et al., 2022). Turning to distrust-based amotivation, while it showed an independent negative association with concurrent vaccination intentions (Schmitz et al., 2022; Van Oost et al., 2022) and prevented a transition to greater vaccination intentions (Waterschoot et al., 2022), there was no unique association with eventual uptake after controlling for the other motivational predictors (Schmitz et al., 2022). Finally, the contribution of effort-based amotivation was systematically limited as it did not yield a unique association with vaccination outcomes, neither concurrently nor longitudinally. Presumably, the effort required for vaccination is rather minimal because it requires a limited time investment, and the distribution of vaccine is well organized in *[country blinded]*.

Motivational Profiles

Although a dimensional approach towards motivation involves separating various types of motivation and the lack thereof to examine their unique contribution, these various motivations and obstacles co-occur among people in reality. A person-centered approach towards motivation

(Vansteenkiste & Mouratidis, 2016) allows shedding complimentary light on the motivational heterogeneity among individuals by identifying motivational profiles, with a profile consisting of a mix of motivations and obstacles for vaccination. Individuals belonging to the same profile share the same pattern of motivations, while those belonging to different profiles display a distinct make-up of motivations.

Prior research in the domains of education (e.g., Ratelle et al., 2007), physical education (Haerens et al., 2010), work (Van den Broeck et al., 2013), and sports (e.g., Lohbeck et al., 2022) has adopted this approach, with the number of identified profiles varying between three and six, depending on the number and type of included motivational dimensions (Vansteenkiste & Soenens, 2023). Across studies, profiles characterized by high autonomous motivation yielded the most clear-cut benefits, while those characterized by high amotivation came with the poorest outcomes. As for controlled motivation, its effects seem to be largely dependent upon the other types of (a)motivation with which it gets combined and upon the outcomes under investigation. When controlled motivation is present next to amotivation, it comes with worse outcomes compared to when high controlled motivation is combined with high autonomous motivation. In the latter case, individuals score high on both types of motivation, with their total amount thus surpassing the motivation of a group characterized by high autonomous motivation only. In spite of their lower dose of motivation, individuals high on autonomous motivation only seemed to fare better on some outcomes (e.g., less test anxiety) compared to the high quantity motivation profile. At the same time, controlled motivation may well push individuals into action, which explains why students belonging to this group exert as much effort on their studies as the good quality motivation group (Vansteenkiste et al., 2009).

In the current study, we aimed to extend this small body of work as no prior study examining individuals' motivational profiles in the context of public health. Further, rather than relying on a single source of amotivation (e.g., Haerens et al., 2010), we included multiple types of amotivation (i.e., effort-based and distrust-based amotivation), with the aim of obtaining a more refined insight in the obstacles for vaccination. After all, even vaccinated individuals form a heterogeneous group, with different impediments playing a role in the hesitation to accept a booster vaccine.

Present Study

Although predictors of people's vaccination intention and effective uptake of first and second dose have been extensively investigated, the question whether people's initial motivation relates to the intention to accept a booster or an annual dose has received, little, if any, attention. The present study comprised two samples and offered the unique opportunity to investigate whether people's vaccination (a)motivation at baseline, i.e., prior to their first dose, relates to their intention to accept the COVID-19 booster dose during the Autumn of 2021 (Sample 1) and their intention to accept an annual dose in March 2022 (Sample 2). We used a mixture of a dimensional and person-centered approach, two methods that allow one to gain a more complete and refined understanding of the motivational dynamics. Whereas a dimensional approach guarantees a better understanding of the key motivational dimensions that uniquely predict the intention to get a booster or annual dose (Aim 1), a person-centered approach allows to develop a multivariate understanding of people's (a)motivations (Aim 2).

As for the dimensional approach, based on prior research (Pelletier et al., 2001) and theorizing (Ryan & Deci, 2017), we expected that autonomous motivation and distrust-based amotivation for the first and second doses would be, respectively, positively and negatively related to the intention to accept third and annual doses several months later. Because the vaccine commitment of individuals high in controlled motivation may be more conditional (e.g., dependent upon granted freedom due to vaccination) and, hence, short-lived, they may be less likely to commit themselves to future injection if such conditional benefits are no longer attached to vaccination. Similarly, while controlled motivated individuals may give in to the salient pressures in the early stage, they may display reactance in the longer run (Brehm & Brehm, 2013) as they felt little ownership over their initial vaccination decision. Regarding effort-based amotivation, and based on past studies on vaccination in [*blinded*], we expected a limited negative contribution, if any.

To provide further evidence for the robust role of motivational differences, we examined in a more explorative fashion whether sociodemographic (i.e., age, gender, civil status, education level) and medical (i.e., infection status) factors would interact with motivational subtypes in the prediction of both vaccination outcomes. We reasoned that the benefits of autonomous motivation might not be dependent on these sociodemographic and medical factors. Rather, the full endorsement and value-based anchoring characteristic of autonomous motivation entails greater commitment and a better handling of encountered obstacles (Bonneville-Roussy et al., 2017; Smith et al., 2011) such that getting infected since vaccination would not prevent individuals from accepting additional doses. In contrast, the experience of a post-vaccine infection may prevent individuals who initially scored high on distrust-based amotivation to accept future doses.

As for the person-centered approach, we built on previous research on motivational profiles (e.g., Vansteenkiste et al., 2009): we expected to find a cluster containing only high scores for autonomous motivation (i.e., the 'good' motivated profile), a cluster only scoring high on controlled motivation (i.e., the 'poor' motivated profile), a cluster having high scores on all types of motivation (i.e., the 'high' motivated profile) and a cluster having high scores of amotivation. Overall, we expected that profiles characterized by higher autonomous motivation would report the strongest intention to accept a booster or an annual dose, while those reporting elevated distrust-based amotivation would report the lowest scores.

Of note, the present test of the motivation – booster/annual dose intention link is rather conservative because there is a substantial -time lag between both measurement moments (i.e., median 265 and 395 days in Samples 1 and 2, respectively). Further, the exclusive sampling of vaccinated persons entails reduced variance and associated predictive power for the motivation measures at baseline compared to the more heterogeneous group used when predicting acceptance of a first dose. Finally, we controlled for the possible impact of various relevant covariates like concurrent risk perception, age (i.e., older people are more willing), gender (i.e., male are more willing), civil status (i.e., singles are less willing), education level (i.e., higher educated are more willing) and infection history (i.e., having no infection yet is associated with a higher intention). We did so because previous research found these factors to have a significant role in vaccination intentions

Method

Participants and Procedure

The current data collection took place in the context of a nation-wide research project called '[*blinded for review*]' in [*blinded*]. Through an online questionnaire, the project monitored various aspects of people's psychological functioning, including their motivation and intention to get a vaccine in case they did not receive a shot yet. We distributed this survey online through advertisements on social media and national newspapers. After an introduction about the content of the research project, participants completed an informed consent explaining that their participation was voluntary (i.e., no monetary reward would be provided), that the data analysis was anonymous, and that they could end their participation anytime without consequences. In addition, we provided contact information in case of questions or negative feelings. We also offered participants to leave their e-mail address for follow-up surveys. Here, we emphasized that we would only use this information for research-related goals and that, after data collection, any identification information would be replaced by an anonymous code. The project received approval from the ethical committee of [blinded] (N° 2020/37).

We worked with two independent samples. Both samples had completed a baseline survey between October 2020 and September 2021. Between October 2021 and January 2021, one part was invited to participate follow-up survey 1, from which we only included the vaccinated participants (i.e., *sample 1*). Another part was invited in March 2022 for follow-up survey 2, from which we also included only the vaccinated participants (i.e., *sample 2*). Based on the mail addresses, we were able to select two unique and non-overlapping sets of participants for samples 1 and 2, in order to conduct a formal replication of the findings, albeit predicting a different outcome.

In the baseline survey, we assessed a set of background variables (i.e., age, gender, civil status, education level, history of infection) and the (lack of) motivation to be vaccinated for the first dose. This was completed by a group of 30,521 participants (M_{age} = 53.58; 63.2% female; 26% being single; 15% being infected). Of these, 27.6% had no education, 38.0% had a Bachelor's degree and 34.4% had a Master's degree. None were vaccinated, as no vaccine was available at that time.

Follow-up survey 1 was completed by 5,597 participants (Response Rate = 18.33%) within a medium period of 265 days (range = 50 – 326 days) after the baseline survey. It included measurements of infection history, risk perception as well as the intention to get the booster dose for those who reported that they had taken the vaccine in the meantime (82%). Among all participants of follow-up survey 1, vaccinated participants (*n* = 4,596, *sample 1*) had a mean age 53.6 years (63.8% female; 23% single), from which 28% had no education or secondary graduation, 38% had a Bachelor's degree and 34% had a Master's degree. In term of infection history, 81% reported to have not been infected with COVID-19 yet, 9% already was infected at the baseline assessment and 10% had been infected in the period between the baseline and follow-up surveys.

Follow-up survey 2 was completed by 732 participants (RR = 2.4%), tapping the same set of background variables, risk perception and intention to get an annual dose for those who reported to be vaccinated in the meantime (70%). Here, the median number of days between both surveys was 395 days (range = 253 – 247 days). Vaccinated participants of follow-up survey 2 (*n* = 514, *sample 2*) had a mean age of 55.9 years (63.7% female; 28% single), from which 27% had no more than secondary school degree, 37% had a Bachelor's degree, and 36% had a Master's degree. Further, 66% reported not having been infected with COVID-19 earlier, 11% had been infected at the time of the baseline survey and 23% had been infected in the meantime. In sample 2, 90% reported having taken the booster dose.

Materials

Sociodemographic variables. In the baseline survey, we assessed participants' age, gender (i.e., male vs. female), civil status (i.e., having a partner or being single), and education level (i.e., from 1 = "No diploma/secondary graduation", 2 = "Bachelor's degree", 3 = "Master's degree/more"). Both follow-up surveys assessed whether they had been infected by COVID-19 and, if so, whether this was before or after their vaccination (i.e., 1 = "no infection", 2 = "pre-vaccine infection", 3 = "post-vaccine infection").

(Lack of) Motivation to get vaccinated. Similar to previous studies (e.g., Schmitz et al., 2022), a total of 12 items captured participants'(a)motivations, with three items measuring autonomous reasons to become vaccinated (e.g., "Getting vaccinated aligns with my personal values") and three items tapping into controlled reasons to get vaccinated (e.g., "I feel pressured to get vaccinated”). Further, three items also measured people’s distrust-based amotivation (e.g., “I am concerned about possible side effects of the vaccine”) and effort-based amotivation (e.g., “I will be criticized if I don’t get vaccinated”). All items had to be rated on a 5-point Likert scale ranging from 1 (totally disagree) to 5 (totally agree). We calculated internal consistencies using Cronbach’s alpha. These were acceptable for each variable (see table 1).

Risk perception. We measured perceptions related to the COVID-19 by asking participants to rate two aspects, namely the estimated risk of infection (from 1 = ‘‘Very small” to 5 = ‘‘Very high”) and the perceived severity of the associated symptoms (from 1 = ‘‘Not at all serious” to 5 = ‘‘Very serious”). They did so for themselves and for the general population, making four items in total (i.e., risk for oneself, risk for others, severity for oneself, severity for others). We aggregated these items to form a total score of risk perception that had good internal consistency (see table 1).

Vaccination intention. For sample 1, participants answered the item “If you were invited for a third shot (or booster vaccination), how would you respond to the invitation?*”* using a 5-point scale: (1) “I would refuse without any hesitation”, (2) “I would probably refuse”, (3) “I would doubt”, (4) “I would probably accept”, (5) “I would accept without any hesitation”. The same response scale was used for sample 2, where participants were asked to answer the item “If you were invited for an annual shot to vaccinate against COVID-19, how would you respond to that invitation?”.

Plan of Analysis

We performed all analyses in R (R Development Core Team, 2022). The syntax is available on https://osf.io/gz64w/?view_only=3d7c926ffac640ce9851392003030a98 [anonymized view-only link]. To check for selectivity, we first conducted a set of comparison analyses among measurements of the baseline survey to compare participants who are included in sample 1 and sample 2 (i.e., those who have taken part to a follow-up survey, respectively, 1 or 2, and being vaccinated at the moment of the follow-up survey) and those who have not taken part. To this end, we used MANOVA for the continuous variable *age* and chi-square tests for the other categorical variables. In a following step, we calculated a Pearson correlation matrix for each sample, including all continuous background variables and the study variables (i.e., types of (a)motivation, vaccination intention). A MANOVA with univariate analyses was used to check for the role of *gender* in the study variables.

As part of the dimensional approach, we performed hierarchical linear regression modeling to examine the associations between vaccination (a)motivation and the intentions to get the booster dose (i.e., in sample 1) or the annual dose (i.e., in sample 2). As a first step, we built a model that included background variables age, education level, gender, civil status, and infection history as predictors, with time difference between both surveys (in days) and risk perception at the follow-up survey as covariates. When predicting the annual dose, we also included whether participants had received their booster dose or not as a covariate. In the second step of the modeling, we added the (a)motivation types as predictors. In the third step, we added two-way interactions between each type of (a)motivation and the other variables of interest. We centered all continuous predictors and used effect coding for the categorical variables (i.e., levels -1 and +1). For each model, we checked the diagnostics (i.e., linearity, normality, heterogeneity, independence) as well as multicollinearity by means of the Variance Inflation Factor (Johnston et al., 2018). We used ANOVA to compare the models and examine whether the newly considered predictors explained additional variance compared to the previous model. In addition, we calculated partial eta-squares for each of the predictors to obtain an effect size next to the estimated coefficients with *p*-values. When an interaction term proved significant, we visualized the moderation effect by calculating the predicted values for different levels of the categorical moderator or by calculating the mean and standard deviations from the mean in case of a continuous moderator. Additionally, we calculated standardized simple slope coefficients for each of the calculated levels.

We performed person-centered analysis on the types of (a)motivation by using the 2-step clustering procedure, which entails using the output of a hierarchical clustering procedure (step 1) as a starting point of the K-Means clustering procedure (step 2; Arai & Barakbah, 2007; Gore, 2000; Waterschoot et al., 2022). As a first step, we excluded all univariate and multivariate detected outliers and standardized all study variables. Then, to select the optimal linkage method for the K-Means clustering step, we relied on the agglomerative coefficient (*ac*), such that the closer the *ac* was to 1, the more optimal the linkage method was.

As part of K-Means clustering procedure (Hartigan & Wong, 1979), we checked the quality and the validity of the clustering procedure before, during, and after the clustering analyses itself. At first, we controlled whether the Hopkins statistics *H* was higher than 0.50, indicating to what extent there is evidence for meaningful clusters (Lawson & Jurs, 1990). Second, we used four validation techniques to consider the optimal number of numbers. Specifically, we relied on the *Elbow method* (i.e. the number of clusters with both a minimum of within-cluster variation and a maximum of between-cluster variation), *the Average Silhouette method* (i.e. the number of clusters with the highest average silhouette, indicating the best quality of clustering; Kaufman & Rousseeuw, 1990), *the Gap statistic method* (i.e. the number of clusters with the highest Gap-statistic; Tibshirani et al., 2001) and *a summary of 30 indices* reporting the most optimal number of clusters using the 'NbClust' function (Charrad et al., 2014), including the CH index (Calinski & Harabasz, 1974). Finally, we checked the Cohen's Kappa-index *k*, which indicates to what extent the cluster solution is stable when performing the same procedure on another part of the same dataset and on the other dataset (e.g., Vansteenkiste et al., 2009). An acceptable cluster stability obtains when *k* is .60 or higher (Asendorpf et al., 2001). We present the result of the clustering procedure by means of a bar plot with the standardized cluster variables as a function of the cluster classification.

In the final step of the analyses, we examined differences between the clusters in terms of the background variables and the study variables. In doing this, we performed a MANCOVA with cluster membership as a predictor, the relevant covariates, and both the current cluster variables (i.e., types of (a)motivation) and the intention to get a booster (i.e., in sample 1) and an annual dose (i.e., in sample 2) as outcomes. In the univariate tests, we conducted post-hoc Tukey tests for multiple comparison in case the predictor 'cluster' had more than 2 levels. To be sure, we applied the Bonferroni correction for *p*-values.

Results

Preliminary Analyses

A baseline comparison between participants of sample 1 (i.e., having participated follow-up survey 1 and being vaccinated in the meantime) and those who did not taken part of follow-up survey 1 (Wilks' lambda = 0.98, F(1, 23345) = 52.73, p<.001) showed that sample 1 participants were significantly older (F(1, 23345) = 281.39, p<.001), had a higher education (F(1, 23345) = 6.75, p=.001), reported higher autonomous motivation ($M_{sample1}$ = 4.08 vs. $M_{no\_followup}$ = 3.89, F(1, 23345) = 17.38, p<.001), lower effort-based ($M_{sample1}$ = 1.47 vs. $M_{no\_followup}$ = 1.53, F(1, 23345) = 6.29, p = .01) and distrust-based ($M_{sample1}$ = 2.56 vs. $M_{no\_followup}$ = 2.75, F(1, 23345) = 27.27, p<.001) amotivation. Further, no differences were found in terms of gender ($\chi^2(1)$= 0.25, p = .61) and infection history at baseline ($\chi^2(2)$= 0.65, p = .72). In line, participants of sample 2 were significantly older (F(1, 23345) = 73.64, p<.001) and had lower scores for distrust-based amotivation ($M_{sample2}$ = 2.54 vs. $M_{no\_followup}$ = 2.72, F(1, 23345) = 9.24, p=.002) compared to those who did not completed the follow-up survey 2. Also here, no differences were found in terms of gender ($\chi^2(1)$=0.10, p = .75) or infection history ($\chi^2(2)$= 7.39, p = .10).

As for the role of sociodemographic background variables within sample 1, a significant multivariate effect was found for gender (Wilks' lambda = 0.97, F[1, 3351] = 17.63, p < .001) and infection history (Wilks' lambda = 0.99, F[2, 4109] = 4.72, p < .001) with female participants scoring higher on distrust-based amotivation (M_{female} = 2.77 versus M_{male} = 2.46, F(1, 3351) = 57.61, p<.001) and those having not been infected yet scoring higher on autonomous motivation ($M_{not\_infected}$ = 4.15 versus $M_{infected\_earlier}$ = 3.93 versus $M_{recently\_infected}$ = 4.06, F(2, 4109) = 6.88, p<.001) and on booster dose intention ($M_{not\_infected}$ = 4.54 versus $M_{infected\_earlier}$ = 4.28 versus $M_{recently\_infected}$ = 4.29, F(2, 4109) = 18.21, p<.001). No effects were found for civil status (Wilks' lambda = 0.99, F[1, 3351] = 1.17, p = .29).

In sample 2, female participants had higher distrust-based amotivation compared to males (M_{female} = 2.70 versus M_{male} = 2.35, F(1, 370) = 8.74, p = .003; Wilks' lambda = 0.95, F[1,372] = 4.31, p < .001) and those having not been infected yet scoring higher on their intention for an annual dose ($M_{not\_infected}$ = 4.02 versus $M_{infected\_earlier}$ = 3.48 versus $M_{recently\_infected}$ = 3.72, F(2, 446) = 5.91, p<.001; Wilks' lambda = 0.95, F[2, 446] = 3.17, p < .001). No effects were found for civil status (Wilks' lambda = 0.95, F[1, 372] = 1.79, p = .24).

Table 1 shows the means, standard deviation and Pearson correlations, with sample 1 represented below the diagonal and sample 2 above the diagonal. A percentual breakdown of participants' intentions to accept a booster dose (5.5% totally refusing, 4.8% refusing, 11.6% doubting, 17% accepting and 61.1% totally accepting) and an annual dose (7.9% totally refusing, 7.0% refusing, 17.1% doubting, 25% accepting and 43% totally accepting) show that most of the participants would (totally) accept the doses, with a higher acceptance rate towards a booster dose. Other variables seem to be quite comparable in terms of their averages. The patterns of correlations are comparable in both samples, with autonomous motivation being related to more intention to get the booster/annual dose and controlled motivation, effort-based amotivation and distrust-based amotivation being related to less intention. When participants are older, they report higher levels of autonomous motivation and vaccination intention, and lower controlled motivation and distrust-based amotivation. One difference between both samples is that a significant relation between controlled motivation and both types of amotivation emerges only in sample 2.

Aim 1: Dimensional Approach

Table 2 shows the output of two linear regression models. We encountered no multicollinearity problems (all VIF's < 1.62) and obtained satisfying model diagnostics. The right part involves the intention for a booster dose as the criterion, while the left part considers the intention to accept an annual dose as the criterion. The findings of both sets of analyses were similar. First, whereas age showed a positive relation with both outcomes, none of the other socio-demographics yielded a unique association, except for time difference, risk perception, and booster uptake. Specifically, the higher the levels of risk perception, the higher the intention to accept a booster dose or an annual dose. For the latter outcome, the intention was also higher for those who got their booster dose in the meantime.

Second, the motivational predictors yielded a similar pattern of unique contributions, with autonomous motivation showing a positive and controlled motivation and distrust-based amotivation showing a negative association with both the intention to get the booster and an annual dose.

Interestingly, the contribution of distrust-based amotivation was much stronger in the prediction of the annual dose.

Third, concerning the interaction effects, their contribution to the models were only significant in predicting booster dose acceptance but proved very small in terms of effect sizes. For instance, a significant interaction effect emerged between levels of autonomous motivation and infection history, showing that individuals who got infected were less willing to accept a booster dose when levels of autonomous motivation were low (see Figure 1). Simple slope analyses revealed no noticeable differences whether this infection was before or after one's vaccination. Second, a significant interaction effect emerged between distrust-based amotivation and infection history in prediction of the annual dose intention, showing that those who had not been infected showed a less marked effect of distrust-based amotivation (see Figure 1S).

Aim 2: Person-centered Analyses

Identification of clusters

The *H*-index for cluster tendency showed evidence for meaningful clusters in both samples ($H_{sample1}$ = .76; $H_{sample2}$ = .73). The *ac* indicates the *Ward*'s method as the best linkage method in both sample 1 (*Ward* = .99; *complete* = .98; *average* = .97; *single* = .94) and sample 2 (*Ward* = .99; *complete* = .96; *average* = .94; *single* = .84).

Next, we calculated the four validation techniques, the results of which are in figure 2S. Results are equivalent for both samples. The Elbow method (upper left) showed evidence for three clusters because there is a balance between the amount of between- and within-cluster variance. The average silhouettes method (upper right) points to six as the most optimal number. However, both the Gap statistic (bottom left) and the majority rule (bottom right) deemed five clusters as the most optimal number. Taking into account that the average silhouette method also provides five as the second-best option, we concluded that five clusters stand as the optimal number of clusters in both sample 1 and sample 2. For this solution, the standardized values for all cluster variables are presented in figure 1A (for sample 1) and figure 1B (sample 2).

The between-cluster comparison in terms of the cluster variables can be found in Table 3A for sample 1 and Table 3B for sample 2. Herein, we notice a comparable output across both samples, with the *Overall amotivated* cluster having the lower scores on autonomous and controlled motivation and the highest scores for both distrust- and effort-based amotivation. The *Controlled+distrust (a)motivation* cluster showed the highest scores on both controlled motivation and distrust-based amotivation, with lower scores for autonomous motivation. The *Effort-based amotivated* cluster showed intermediate scores for autonomous motivation, controlled motivation, and distrust-based amotivation along with the highest scores for effort-based amotivation. Similar to the *Good quality motivation* cluster, the *High quantity motivation* cluster had the lowest scores for both types of amotivation, but significantly higher scores for controlled motivation.

Also, the proportion of participants assigned to a particular cluster seems comparable across both samples, with both the *Good quality motivation* and *High quantity motivation* as the two biggest clusters in sample 1 (resp. 35% and 22%) and sample 2 (resp. 29% and 33%). The *Effort-based amotivated* cluster contains an intermediate proportion of participants (resp. 19% and 17%), followed by the *Controlled+distrust-based (a)motivated* cluster (resp. 14% and 13%) with the *Overall amotivated* cluster as the smallest cluster (resp. 10% and 8%).

One difference between both samples is that the *High quantity motivation* cluster had significantly higher scores for autonomous motivation in sample 1, compared to the cluster differences in sample 2. Also, the *Overall amotivated* cluster showed higher scores on distrust-based amotivation than the *Controlled+distrust (a)motivation* cluster in sample 2, while both had equal scores in sample 2.

The double-split cross-validation procedure to determine cluster stability revealed a weighted k of .86 (z = 111.06, p <.001) for subset A and a weighted k of .85 (z = 110.30, p <.001) for subset B in sample 1. In sample 2, a weighted k of .98 (z = 120.3, p <.001) for subset A and a weighted k of .94 (z = 51.26, p <.001) for subset B was found. When checking this between samples, we found a weighted k of .98 (z = 491.8, p <.001) for sample 1 and a weighted k of .99 (z = 546.1, p <.001) for sample 2. As a set, these analyses indicate a good cluster stability.

Between-cluster differences

Background variables. When comparing the clusters in terms of background variables in sample 1, a significant chi-square test for gender ($\chi^2(4)$= 31.40, p <.001) confirmed that the *High quantity motivation* cluster comprised more male participants and the *Controlled+distrust (a)motivation* cluster comprised more females, compared to the proportions observed in the other clusters (see table 1S). No effects emerged for civil status ($\chi^2(4)$= 2.14, p = .32) and infection history ($\chi^2(8)$= 14.11, p = .09). In sample 2, we found no significant chi-square tests ($\chi^2_{gender}(4)$= 3.81, p = .43; $\chi^2_{civil\ status}$ (4)= 5.43, p = .25; $\chi^2_{infection\ history}$ (8)= 10.89, p = .21). In both samples, the *Controlled+distrust (a)motivation* sample had a significantly lower age and the lowest scores for risk perception. Remarkably, both the *Good quality motivation*, *High quantity motivation* and *Effort-based amotivated* clusters had equal scores for risk perception. Only in sample 1, a significant effect for education level shows that the *Good quality motivation* and *High quantity motivation* clusters had the highest education levels.

Vaccination intention. To examine between-cluster differences in terms of the intention to accept a booster or an annual dose of the COVID-19 vaccine, we performed linear regression modeling to calculate the between-cluster means and differences, while controlling for the covariates. The means and multiple comparison test (in tables 3A and 3B, respectively) reveal that both the *Good quality motivation* and the *High quantity motivation* clusters displayed the highest intentions in both samples, followed by the *Effort-based amotivated* cluster. The *Controlled+distrust (a)motivation* and *Overall amotivated clusters* had the lowest intentions, with the *Overall amotivated* cluster scoring significantly the lowest in sample 1.

Discussion

The waning of COVID-19 vaccine immunity after the initial doses of vaccine, together with the emergence of more infectious and vaccine-resistant variants, prompted the need for additional doses in order to keep the pandemic under control and to protect the national healthcare system (Callaway, 2021). In spite of clear benefits, not everyone was willing to get a new shot, let alone, an annual shot. This situation triggered the question regarding the factors underlying the heterogeneity in continued vaccine acceptance among vaccinated persons. Although a large body of the research on COVID-19 vaccination intentions, including the acceptance of booster dose and annual doses, points to the role of sociodemographic, medical and political factors, other work has been focusing on psychological factors, like the perception of risk or the motivation to be vaccinated. Indeed, previous findings confirmed the role of motivational factors (e.g., Schmitz et al., 2022), pointing to autonomous motivation and distrust-based amotivation as key determinants of one's intention to accept the COVID-19 vaccine. Yet, very few research has focused on booster dose and annual dose intentions, and to our knowledge, no study has examined the effect of motivations on these important outcomes. In the present study, we questioned the robustness of motivational effects towards the acceptance of a booster and an annual dose in light of the latest pandemic phases and of the role of other factors influencing intention for a new or annual dose. We examined this issue using two samples in which we linked participants' first dose vaccination motivation and amotivation with their intention to get a booster dose or an annual dose.

A Dimensional approach

In line with previous findings, initial autonomous motivation and distrust-based amotivation predicted, respectively, positively and negatively respondents' intention to accept both a booster dose and an annual dose, even among vaccinated individuals and even when controlling for the number of days between both measurements and participants' risk perception. Interestingly, controlled motivation had a unique negative contribution, a finding that is partially discrepant and partially consistent with prior work focusing on the first dose (e.g., Van Oost et al., 2022; Waterschoot et al., 2022). Indeed, research in other life domains like sports (Pelletier et al., 2001) or education (Vansteenkiste et al., 2005) has shown that the effects of controlled motivation are rather short-lived and may backfire over time. The acceptance of a booster or an annual dose depends on continued commitment and feeling initially seduced into vaccination through controlling forces may lead people to give up on later occasions (Ryan et al., 2021).

Next to motivation, there were also other factors influencing people's intention for a booster or an annual dose, including the perceived risk for (severe) illness at the time of the follow-up assessment. Further, similar to previous research, the older people were, the more they were willing to envision a booster dose or an annual dose. Interestingly, interaction effects with both factors underscore the robust role of autonomous motivation, such that whether or not people already experienced a COVID-19 infection, and whether this infection took place before or after their vaccination, higher autonomous motivation was systematically associated with higher vaccination intention whereas higher distrust-based amotivation materialized into lower vaccination intention.

Finally, effort-based amotivation had no unique effect on the target outcomes. Because people thought that vaccination required little effort and time as the distribution of vaccines was made logistically easy (e.g., by implementing numerous vaccination centers), it seems logical that effort-based amotivation played no role.

A Person-Centered Approach

In line with our second aim, we also adopted a person-centered approach using a two-step procedure of clustering analyses in both samples. A set of validation techniques suggested the presence of five meaningful clusters and indeed similar clustering patterns in both samples. Interestingly, the same set of clusters emerged with most of the participants being assigned to the *Good* and *Highly* motivated clusters. These two groups had, respectively, uniquely high scores on autonomous motivation and a combination between both types of motivation. Although the dimensional analyses revealed a unique negative effect of controlled motivation, the combination of autonomous motivation with controlled motivation did not reveal any significant differences in terms of the intentions to get the booster and an annual dose. Presumably, the presence of autonomous motivation helps to offset possible negative effects of controlled motivation. Alternatively, the negative effect of controlled motivation depends more on the presence of other motivational factors. Indeed, controlled motivation had a negative effect when combined with high levels distrust-based amotivation, resulting in low levels of vaccination intentions in both samples. As expected, this is a group of people who experienced feelings of distrust towards the vaccine, while feeling externally pressured to accept their first shots. Furthermore, this cluster did not differ significantly in terms of vaccination intention from the group with high scores on both distrust- and effort-based amotivation.

In line with the dimensional approach, this finding suggests that distrust, even in combination with a sense of obligation towards the vaccine had a strong negative influence on people's intention to get a booster or an annual dose. This is particularly clear when observing the effects for the *Effort-based amotivated* cluster. This cluster shows intermediate scores for the other types of motivation but also for people's acceptance towards a booster or an annual dose. As such, this cluster comprises a group of people who remain largely undecided with respect to taking additional doses.

Limitations

Unsurprisingly, the present study suffers from a number of limitations. Although we relied on several national newspapers and social media ads to reach our participants, our sample is not representative of the population. In particular, it comprises an excess of female participants and of higher educated people. The number of people in Sample 2 who took the booster shot (90%) also illustrates this limitation, given that only 62% of the [blinded for review] population have actually the invitation. Also, because only those already being vaccinated participated the current study, the present sample is rather committed and, therefore, selective.

Second, our results might in part reflect the cultural context in which they were collected. For instance, the [*blinded*] infrastructure that supported the vaccination campaign effort may account for the non-significant role of effort.

Third, one cannot exclude the possibility of a recall bias, such that the participants of both samples were those who were motivated enough to participate after being contacted. It might be that these individuals held overall different attitudes towards vaccination than other people. Along similar lines, we do not account for possible changes in people's (lack of) motivation to be vaccinated. As the literature suggests, several factors like one's history with COVID-19 or exposure to types of information might trigger a shift in one's motivation to get the vaccine across time.

Fourth, the reported results concern participants' intention. Admittedly, on top of being possibly tainted by social desirability, intention may also fail to materialize into actual behavior. Although hardly any studies investigate the issue of the acceptance of a vaccination booster, there is a need for more work to that pins down its antecedents, both on a variety of samples and for a range of delays.

Practical Implications

In spite of the available evidence showing the effectiveness and critical role of boosters against circulating variants, acceptance rates for boosters remain well below those observed for the first dose, even among vaccinated adults. Yet, the emergence of new COVID variants is an ever-present risk. More generally, the increased danger of emergence of new infectious epidemics (Jones et al., 2008; Morse et al., 2012), and the current presence of monkeypox, suggest that successful and long-lasting vaccination campaigns will continue to be a challenge for years to come. In this context, identifying predictors of vaccine booster and annual dose acceptance is crucial. Our study highlights the critical role of autonomous motivation in fostering intention to accept a booster dose over the long run. Autonomous motivation shows a protective role against some factors associated with lower vaccination intentions (gender, young age). It also remains important to inform the public adequately about the benefits (and potential caveats) of booster vaccines and to provide an adequate perception of the risks involved (despite its volatile nature) in order to dispel potential distrust and to foster an internalized sense of willingness.

The clear lesson emanating from the existing research emphasizes the greater effectiveness of autonomy-supportive rather than coercion-based communication style to encourage vaccine uptake (e.g., Martela et al., 2021). In line with this message, we found that controlled motivation had a unique negative influence on booster acceptance, thus suggesting that sanctions and rewards come as a perilous game because they can backfire after a few months. In sharp contrast, several authors underline the positive effect of prosocial motives for vaccination (e.g., Motta et al., 2021).

At the same time, the choice of a booster and access to vaccination in general is by no means a socioeconomic neutral issue. While our results suggest that older, female adults are more reluctant to take a booster injection, other results also indicate that adults from lower socio-economic backgrounds are more reluctant. This is in spite of the fact that these portions of the population are most likely to suffer from serious indirect consequences from the virus (Paul & Fancourt, 2022). Similarly, and although it is crucial to foster vaccination for everyone, experts legitimately warn against the major inequalities in vaccine availability beyond borders, with a number of countries delivering booster doses while southern, low-income countries are still severely under-vaccinated (e.g., Juno & Wheatley, 2021). Future research could examine whether this perceived inequality of access might also be a possible concern for vaccinated people and as such a cause for booster and repeated vaccination amotivation.

Conclusion

Building upon Self-Determination theory, we presently explored motivational predictors of booster acceptance and annual COVID-19 vaccination dose, using longitudinal data collected between October 2020 and March 2022. Our results highlight the strong beneficial role of autonomous motivation, such that participants who were autonomously motivated to take their initial dose reported higher rates of booster and annual dose acceptance months later. Conversely, controlled motivation had a negative contribution, especially when being combined with distrust-based amotivation. The present data offer strong evidence that autonomous motivation plays a sustainable positive effect and that controlling strategies, such as sanctions or rewards, are potentially counterproductive over time. In light of the continued risk of future outbreaks, our findings point to the importance of attending to the promotion of vaccination for all.

Declarations

Conflict of interest

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

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- **Joachim Waterschoot:** Conceptualization, Methodology, Software, Formal analysis, Investigation, Data Curation, Writing - Original Draft, Writing - Review & Editing, Visualization

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References

Abuhammad, S., Khabour, O. F., Alzoubi, K. H., Hamaideh, S., Alzoubi, B. A., Telfah, W. S., & El-Zubi, F. K. (2022). The public's attitude to and acceptance of periodic doses of the COVID-19 vaccine: A survey from Jordan. *PLoS One, 17*(7), e0271625.

Al Janabi, T., & Pino, M. (2021). Predictors for actual COVID-19 vaccine uptake and intended booster dosage among medical students of an osteopathic medical school in New York. *Epidemiologia, 2*(4), 553-563. https://doi.org/10.3390/epidemiologia2040038

Andrews, N., Stowe, J., Kirsebom, F., Toffa, S., Sachdeva, R., Gower, C., ... & Lopez Bernal, J. (2022). Effectiveness of COVID-19 booster vaccines against COVID-19-related symptoms, hospitalization and death in England. *Nature medicine, 28*(4), 831-837. https://doi.org/10.1038/s41591-022-01699-1

Arai, K., & Barakbah, A., R. (2007). Hierarchical K-means: an algorithm for cen- troids initialization for K-means. *Reports of the Faculty of Science and Engineering, 36*(1), 25–31.

Asendorpf, J. B., Borkenau, P., Ostendorf, F., & Van Aken, M. A. (2001). Carving personality description at its joints: Confirmation of three replicable personality prototypes for both children and adults. *European Journal of personality, 15*(3), 169-198.

Bar-On, Y. M., Goldberg, Y., Mandel, M., Bodenheimer, O., Freedman, L., Kalkstein, N., Mizrahi, B., Alroy-Preis, S., Ash, N., Milo, R., & Huppert, A. (2021a). Protection of BNT162b2 Vaccine Booster against Covid-19 in Israel. *New England Journal of Medicine, 385*(15), 1393-1400. https://doi.org/10.1056/NEJMoa2114255

Bonneville-Roussy, A., Evans, P., Verner-Filion, J., Vallerand, R. J., & Bouffard, T. (2017). Motivation and coping with the stress of assessment: Gender differences in outcomes for university students. *Contemporary educational psychology, 48*, 28-42. https://doi.org/10.1016/j.cedpsych.2016.08.003

Brehm, S. S., & Brehm, J. W. (2013). *Psychological reactance: A theory of freedom and control*. Academic Press.

Caliński, T., & Harabasz, J. (1974). A dendrite method for cluster analysis. *Communications in Statistics-theory and Methods, 3*(1), 1-27.

Callaway, E. (2021). COVID vaccine boosters : The most important questions. *Nature, 596*(7871), 178-180. https://doi.org/10.1038/d41586-021-02158-6

Charrad, M., Ghazzali, N., Boiteau, V., & Niknafs, A. (2014). NbClust: an R package for determining the relevant number of clusters in a data set. *Journal of statistical software, 61*, 1-36. https://doi.org/10.18637/jss.v061.i06

Folcarelli, L., Miraglia del Giudice, G., Corea, F., & Angelillo, I. F. (2022). Intention to receive the COVID-19 vaccine booster dose in a university community in Italy. *Vaccines, 10*(2), 146. https://doi.org/10.3390/vaccines10020146

Gore, P. A., Jr. (2000). Cluster analysis. In H. E. A. Tinsley & S. D. Brown (Eds.), Handbook of applied multivariate statistics and mathematical modeling (pp. 297–321). *Academic Press*. https://doi.org/10.1016/B978-012691360-6/50012-4

Griffin, J. B., Haddix, M., Danza, P., Fisher, R., Koo, T. H., Traub, E., Gounder, P., Jarashow, C., & Balter, S. (2021). SARS-CoV-2 Infections and Hospitalizations Among Persons Aged ≥16 Years, by Vaccination Status - Los Angeles County, California, May 1-July 25, 2021. *MMWR. Morbidity and mortality weekly report*, *70*(34), 1170–1176. https://doi.org/10.15585/mmwr.mm7034e5

Haerens, L., Kirk, D., Cardon, G., De Bourdeaudhuij, I., & Vansteenkiste, M. (2010). Motivational profiles for secondary school physical education and its relationship to the adoption of a physically active lifestyle among university students. *European Physical Education Review, 16*(2), 117-139. https://doi.org/10.1177/1356336X10381304

Hartigan, J. A., & Wong, M. A. (1979). Algorithm AS 136: A k-means clustering algorithm. *Journal of the royal statistical society. series c (applied statistics), 28*(1), 100-108.

Johnston, R., Jones, K., & Manley, D. (2018). Confounding and collinearity in regression analysis: a cautionary tale and an alternative procedure, illustrated by studies of British voting behaviour. *Quality & quantity*, *52*(4), 1957-1976. https://doi.org/10.1007/s11135-017-0584-6

Jones, K. E., Patel, N. G., Levy, M. A., Storeygard, A., Balk, D., Gittleman, J. L., & Daszak, P. (2008). Global trends in emerging infectious diseases. *Nature, 451*(7181), 990-993. https://doi.org/10.1038/nature06536

Juno, J. A., & Wheatley, A. K. (2021). Boosting immunity to COVID-19 vaccines. *Nature medicine, 27*(11), 1874-1875. https://doi.org/10.1038/s41591-021-01560-x

Kaufman, L., & P.J. Rousseeuw (1990). Finding Groups in Data. John Wiley & Sons, New York.

Krause, P. R., Fleming, T. R., Peto, R., Longini, I. M., Figueroa, J. P., Sterne, J. A. C., Cravioto, A., Rees, H., Higgins, J. P. T., Boutron, I., Pan, H., Gruber, M. F., Arora, N., Kazi, F., Gaspar, R., Swaminathan, S., Ryan, M. J., & Henao-Restrepo, A.-M. (2021). Considerations in boosting COVID-19 vaccine immune responses. *The Lancet*, *398*(10308), 1377-1380. https://doi.org/10.1016/S0140-6736(21)02046-8

Lawson, R. G., & Jurs, P. C. (1990). New index for clustering tendency and its application to chemical problems. *Journal of chemical information and computer sciences, 30*(1), 36-41. https://doi.org/10.1021/ci00065a010

Legault, L., Green-Demers, I., & Pelletier, L. (2006). Why do high school students lack motivation in the classroom? Toward an understanding of academic amotivation and the role of social support. *Journal of educational psychology*, *98*(3), 567. https://doi.org/10.1037/0022-0663.98.3.567

Lohbeck, A., Hohmann, A., von Keitz, P., & Daseking, M. (2022). Children's Motivation Profiles in Sports and Physical Activities: A Latent Profile Analysis and Self-Determination Theory Approach. *Journal of Sport and Exercise Psychology, 1*(aop), 1-12. https://doi.org/10.1123/jsep.2021-0279

Martela, F., Hankonen, N., Ryan, R. M., & Vansteenkiste, M. (2021). Motivating voluntary compliance to behavioural restrictions: Self-determination theory–based checklist of principles for COVID-19 and other emergency communications. *European Review of Social Psychology, 32*(2), 305-347. https://doi.org/10.1080/10463283.2020.1857082

Milošević Đorđević, J., Mari, S., Vdović, M., & Milošević, A. (2021). Links between conspiracy beliefs, vaccine knowledge, and trust: Anti-vaccine behavior of Serbian adults. *Social Science & Medicine (1982), 277,* 113930. https://doi.org/10.1016/j.socscimed.2021.113930

Morse, S. S., Mazet, J. A., Woolhouse, M., Parrish, C. R., Carroll, D., Karesh, W. B., ... & Daszak, P. (2012). Prediction and prevention of the next pandemic zoonosis. *The Lancet, 380*(9857), 1956-1965. https://doi.org/10.1016/S0140-6736(12)61684-5

Motta, M., Sylvester, S., Callaghan, T., & Lunz-Trujillo, K. (2021). Encouraging COVID-19 vaccine uptake through effective health communication. *Frontiers in Political Science, 3,* 1. https://doi.org/10.3389/fpos.2021.630133

Pal, S., Shekhar, R., Kottewar, S., Upadhyay, S., Singh, M., Pathak, D., ... & Sheikh, A. B. (2021). COVID-19 vaccine hesitancy and attitude toward booster doses among US healthcare workers. *Vaccines, 9*(11), 1358. https://doi.org/10.3390/vaccines9111358

Patalon, T., Saciuk, Y., Peretz, A., Perez, G., Lurie, Y., Maor, Y., & Gazit, S. (2022). Waning effectiveness of the third dose of the BNT162b2 mRNA COVID-19 vaccine. *Nature Communications, 13*(1), 1-7. https://doi.org/10.1038/s41467-022-30884-6

Paul, E., & Fancourt, D. (2022). Predictors of uncertainty and unwillingness to receive the COVID-19 booster vaccine: An observational study of 22,139 fully vaccinated adults in the UK. The *Lancet Regional Health-Europe, 14,* 100317. https://doi.org/10.1016/j.lanepe.2022.100317

Pelletier, L. G., Dion, S., Tuson, K., & Green-Demers, I. (1999). Why do people fail to adopt environmental protective behaviors? Toward a taxonomy of environmental amotivation 1. *Journal of applied social psychology, 29*(12), 2481-2504. https://doi.org/10.1111/j.1559-1816.1999.tb00122.x

Pouwels, K. B., Pritchard, E., Matthews, P. C., Stoesser, N., Eyre, D. W., Vihta, K. D., ... & Walker, A. S. (2021). Effect of Delta variant on viral burden and vaccine effectiveness against new SARS-CoV-2 infections in the UK. *Nature medicine, 27*(12), 2127-2135. https://doi.org/10.1038/s41591-021-01548-7

R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ratelle, C. F., Guay, F., Vallerand, R. J., Larose, S., & Senécal, C. (2007). Autonomous, controlled, and amotivated types of academic motivation: A person-oriented analysis. *Journal of educational psychology, 99*(4), 734. https://doi.org/10.1037/0022-0663.99.4.734

Reifferscheid, L., Lee, J. S. W., MacDonald, N. E., Sadarangani, M., Assi, A., Lemaire-Paquette, S., & MacDonald, S. E. (2022). Transition to endemic: acceptance of additional COVID-19 vaccine doses among Canadian adults in a national cross-sectional survey. *BMC public health, 22*(1), 1-15.

Riemersma, K. K., Grogan, B. E., Kita-Yarbro, A., Halfmann, P. J., Segaloff, H. E., Kocharian, A., ... & Grande, K. M. (2021). Shedding of infectious SARS-CoV-2 despite vaccination. *MedRXiv*. https://doi.org/10.1101/2021.07.31.21261387

Ryan, R. M., & Deci, E. L. (2017). *Self-determination theory: Basic psychological needs in motivation, development, and wellness*. Guilford Publications.

Ryan, R. M., Deci, E. L., Vansteenkiste, M., & Soenens, B. (2021). Building a science of motivated persons: Self-determination theory's empirical approach to human experience and the regulation of behavior. *Motivation Science, 7*(2), 97. https://doi.org/10.1037/mot0000194<

Rzymski, P., Poniedziałek, B., & Fal, A. (2021). Willingness to Receive the Booster COVID-19 Vaccine Dose in Poland. *Vaccines*, *9*(11), 1286. https://doi.org/10.3390/vaccines9111286

Schmitz, M., Luminet, O., Klein, O., Morbée, S., Van den Bergh, O., Van Oost, P., ... & Vansteenkiste, M. (2022). Predicting vaccine uptake during COVID-19 crisis: A motivational approach. *Vaccine, 40*(2), 288-297. https://doi.org/10.1016/j.vaccine.2021.11.068

Sprengholz, P., Henkel, L., & Betsch, C. (2022). Payments and freedoms: Effects of monetary and legal incentives on COVID-19 vaccination intentions in Germany. *Plos one, 17*(5), e0268911. https://doi.org/10.1371/journal.pone.0268911

Smith, A. L., Ntoumanis, N., Duda, J. L., & Vansteenkiste, M. (2011). Goal striving, coping, and well-being: A prospective investigation of the self-concordance model in sport. *Journal of Sport & Exercise Psychology, 33,* 124-145 https://doi.org/10.1123/jsep.33.1.124

Su, Z., McDonnell, D., Cheshmehzangi, A., Li, X., Maestro, D., Šegalo, S., ... & Hao, X. (2021). With great hopes come great expectations: Access and adoption issues associated with COVID-19 vaccines. *JMIR Public Health and Surveillance, 7*(8), e26111. https://doi.org/10.2196/26111

Sugawara, N., Yasui-Furukori, N., Fukushima, A., & Shimoda, K. (2021). Attitudes of Medical Students toward COVID-19 Vaccination: Who Is Willing to Receive a Third Dose of the Vaccine? *Vaccines, 9*(11), 1295. MDPI AG. Retrieved from http://dx.doi.org/10.3390/vaccines9111295

Tibshirani, R., Walther, G., & Hastie, T. (2001). Estimating the number of clusters in a data set via the gap statistic. *Journal of the Royal Statistical Society: Series B (Statistical Methodology), 63*(2), 411-423. https://doi.org/10.1111/1467-9868.00293

Toro-Ascuy, D., Cifuentes-Muñoz, N., Avaria, A., Pereira-Montecinos, C., Cruzat, G., Peralta-Arancibia, K., ... & Fuenzalida, L. F. (2022). Factors Influencing the Acceptance of COVID-19 Vaccines in a Country with a High Vaccination Rate. *Vaccines, 10*(5), 681.

Van den Broeck, A., Lens, W., De Witte, H., & Van Coillie, H. (2013). Unraveling the importance of the quantity and the quality of workers' motivation for well-being: A person-centered perspective. *Journal of Vocational Behavior, 82*(1), 69-78. https://doi.org/10.1016/j.jvb.2012.11.005

Van Oost, P., Yzerbyt, V., Schmitz, M., Vansteenkiste, M., Luminet, O., Morbée, S., ... & Klein, O. (2022). The relation between conspiracism, government trust, and COVID-19 vaccination intentions: The key role of motivation. *Social Science & Medicine*, 114926. https://doi.org/10.1016/j.socscimed.2022.114926

Vansteenkiste, M., Lens, W., & Deci, E. L. (2006). Intrinsic versus extrinsic goal-contents in Self-Determination Theory: Another look at the quality of academic motivation. *Educational Psychologist, 41,* 19-31. https://doi.org/10.1207/s15326985ep4101_4

Vansteenkiste, M. & Mouratidis, A. (2016). Emerging trends and future directions for the field of motivation psychology: A special issue in honor of Prof. Dr. Willy Lens. Psychologica Belgica. 56, 317–341 https://doi.org/10.5334/pb.354

Vansteenkiste, M., Sierens, E., Soenens, B., Luyckx, K., & Lens, W. (2009). Motivational profiles from a self-determination perspective: The quality of motivation matters. *Journal of Educational Psychology*, *101*(3), 671–688. https://doi.org/10.1037/a0015083

Vansteenkiste, M., Zhou, M., Lens, W., & Soenens, B. (2005). Experiences of autonomy and control among Chinese learners: Vitalizing or immobilizing? *Journal of Educational Psychology, 97,* 468-483. https://doi.org/10.1037/0022-0663.97.3.468

Waterschoot, J., Morbée, S., Vermote, B., Brenning, K., Flamant, N., Vansteenkiste, M., & Soenens, B. (2022). Emotion regulation in times of COVID-19: A person-centered approach based on self-determination theory. *Current Psychology*, 1-15.

Waterschoot, J., Yzerbyt, V., Soenens, B., Van den Bergh, O., Morbée, S., Schmitz, M., Van Oost, P., Luminet, O., Klein, O., & Vansteenkiste, M. (2022). How do vaccination intentions change over time? The role of motivational growth. *Health Psychology*. Advance online publication. https://doi.org/10.1037/hea0001228

Wu, F., Yuan, Y., Deng, Z., Yin, D., Shen, Q., Zeng, J., ... & Sun, C. (2022). Acceptance of COVID-19 booster vaccination based on the protection motivation theory: A cross-sectional study in China. *Journal of medical virology*, *94*(9), 4115-4124. https://doi.org/10.1002/jmv.27825

Zintel, S., Flock, C., Arbogast, A. L., Forster, A., von Wagner, C., & Sieverding, M. (2022). Gender differences in the intention to get vaccinated against COVID-19: A systematic review and meta-analysis. *Journal of Public Health*, 1-25. https://doi.org/10.1007/s10389-021-01677-w

Tables

Table 1. *Pearson correlations between Study Variables for Sample 1 (below diagonal) and Sample 2 (above diagonal)*

	Sample 1			***Sample 2***									
	M	*SD*	α	*M*	*SD*	α	1.	2.	3.	4.	5.	6.	7.
1. Age	53.58	12.83	-	55.90	13.09	-		-.21***	.16**	-.07	-.03	-.12*	.30***
2. Education level	2.10	0.85	-	2.22	0.86	-	-.18***		.09	.05	-.07	-.10*	-.10*
3. Autonomous motivation	3.19	0.85	.72	2.89	0.72	.73	.09***	.10***		.00	-.43***	-.74***	.69***
4. Controlled motivation	4.08	1.12	.84	4.02	1.21	.81	-.09***	.07***	.05**		.07	.08	-.07
5. Effort-based amotivation	3.06	0.69	.69	3.06	0.69	.71	-.03	-.10***	-.41***	.09***		.50***	-.35***
6. Distrust-based amotivation.	1.47	0.65	.74	1.52	0.71	.76	-.15***	-.12***	-.70***	.11***	.43***		-.57***
7. Vaccination intention	2.56	1.16	.77	2.54	1.14	.74	.19***	.02	.59***	-.05**	-.28***	-.44***	

Note. ***p <.001, **p <. 01, *p < .05

Table 2. *Standardized Beta-coefficients and Partial Eta-squared of Linear Regression Models.*

	Booster dose intention						***Annual dose intention***					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
Age	.12 ***	(.02)	.05 *	(.00)	.06 **	(.00)	.18 ***	(.04)	.12 **	(.03)	.14 ***	(.15)
Education	.10 ***	(.01)	.01	(.00)	.02	(.00)	.03	(.00)	-.07	(.01)	-.06	(.04)
Gender	-.12 *	(.00)	.00	(.00)	.00	(.00)	-.08	(.01)	-.02	(.00)	-.01	(.00)
Civil status	.08	(.00)	.09	(.00)	.08	(.00)	-.01	(.00)	.04	(.00)	.03	(.00)
Infection history [post-vaccine]	.09	(.00)	.05	(.00)	.05	(.00)	.05	(.00)	.02	(.00)	.02	(.02)
Infection history [pre-vaccine]	-.02		-.04		-.05		-.02		.02		.02	
Time difference	.09 ***	(.01)	.06 **	(.01)	.06 **	(.01)	.02	(.00)	.04	(.01)	.04	(.01)
Risk perception	.37 ***	(.13)	.24 ***	(.08)	.24 ***	(.08)	.32 ***	(.11)	.19 ***	(.06)	.16 ***	(.00)
Booster [received]							.30 ***	(.11)	.10 **	(.02)	.09 *	(.00)
Autonomous Motivation (AM)			.43 ***	(.12)	.48 ***	(.11)			.45 ***	(.14)	.46 ***	(.00)
Controlled motivation (CM)			-.07 **	(.02)	-.06 **	(.02)			-.09 **	(.00)	-.08 **	(.01)
Effort-based Amotivation (EB AM)			.00	(.00)	.01	(.00)			-.00	(.00)	.04	(.01)
Distrust-based Amotivation (DB AM)			-.13 **	(.01)	-.17 **	(.01)			-.24 ***	(.04)	-.28 ***	(.04)
AM*age					-.03	(.00)					.00	(.00)
CM*age					-.01	(.00)					.00	(.00)
EB AM*age					-.01	(.00)					.03	(.00)
DB AM*age					.04	(.00)					-.01	(.00)
AM*education					.02	(.00)					-.03	(.00)
CM*education					.01	(.00)					.05	(.00)
EB AM*education					.00	(.00)					.11	(.02)
DB AM*education					.05	(.00)					-.07	(.00)
AM*gender					.05	(.00)					-.02	(.00)
CM*gender					-.01	(.00)					.06	(.00)
EB AM*gender					-.03	(.00)					-.06	(.00)
DB AM*gender					.03	(.00)					.13	(.00)

AM*civil status			-.04 (.00)			-.06 (.00)
CM* civil status			.05 (.01)			.03 (.00)
EB AM* civil status			-.02 (.00)			.03 (.00)
DB AM* civil status			-.05 (.00)			.00 (.00)
AM* infection history [after vaccination]			-.11 * (.00)			.03 (.01)
AM* infection history [before vaccination]			-.04			-.02
CM* infection history [after vaccination]			-.04 (.00)			-.02 (.00)
CM* infection history [before vaccination]			.02			.04
EB AM* infection history [after vaccination]			.02 (.00)			.09 (.00)
EB AM* infection history [before vaccination]			-.02			.07
DB AM* infection history [after vaccination]			.03 (.00)			.15 ** (.01)
DB AM* infection history [before vaccination]			-.09			-.11 **
R^2	.19 / .19	.44 / .44	.45 / .45	.31 / .30	.57 / .55	.60 / .59
Comparison test		$F(4)=154.12$, $p<.001$	$F(24)=1.84$ $p<.001$		$F(4)=140.78$, $p<.001$	$F(24)=1.10$, $p=.34$

*Note****p* <.001, ***p* <. 01, * *p* <. 05

Table 3A. *Descriptives and output of univariate analyses of between-cluster comparisons in sample 1*

	Motivational Profiles					**F**	***p*-value**	η^2_p
	Good quality motivation	High quantity motivation	Effort-based amotivation	Controlled + distrust-based (a)motivation	Overall amotivated			
Covariates								
Age	54.78^{b}	54.97^{b}	53.82^{b}	49.11^{a}	52.76^{b}	19.66	<.001	.02
Education level	2.14^{c}	2.22^{c}	2.01^{b}	2.12^{bc}	1.83^{a}	14.38	<.001	.02
Time difference	272.22^{a}	273.94^{ab}	278.64^{b}	276.1^{ab}	279.02^{ab}	2.80	.02	.00
Risk perception	3.30^{c}	3.28^{c}	3.26^{c}	3.08^{b}	2.78^{a}	51.13	<.001	.06
Cluster variables (raw scores)								
Autonomous motivation	4.69^{d}	4.81^{e}	4.11^{c}	3.10^{b}	1.77^{a}	1088.4	<.001	.73
Controlled motivation	2.54^{a}	3.72^{c}	3.01^{b}	3.71^{c}	2.53^{a}	1648.5	<.001	.59
Distrust-based amotivation	1.87^{a}	1.90^{a}	2.75^{b}	3.93^{c}	4.20^{d}	1696.01	<.001	.60
Effort-based amotivation	1.07^{a}	1.13^{b}	2.20^{e}	1.54^{c}	2.10^{d}	1308.84	<.001	.53
Cluster variables (z-scores)								
Autonomous motivation	0.53	-0.90	0.02	0.63	-2.09			
Controlled motivation	-0.75	0.97	-0.07	0.98	-0.74			
Distrust-based amotivation	-0.59	1.19	0.16	-0.57	1.41			
Effort-based amotivation	-0.61	0.13	1.14	-0.52	0.96			
Outcome								
Booster vaccination intention	4.57^{d}	4.61^{d}	4.31^{c}	3.62^{b}	3.02^{a}	160.75	<.001	.24

Table 3B. *Descriptives and output of univariate analyses of between-cluster comparisons in sample 2*

	Clusters					**F**	***p*-value**	η^2_p
	Good quality motivation	High quantity motivation	Effort-based amotivation	Controlled + distrust-based (a)motivation	Overall amotivated			
Covariates								
Age	56.95[b]	56.73[b]	58.05[b]	49.20[a]	55.18[ab]	4.09	<.001	.04
Education level	2.29	2.27	2.19	2.20	1.94	1.22	.30	.01
Time difference	386.19[ab]	382.67[ab]	388[ab]	368.78[a]	397.64[b]	2.71	.03	.02
Risk perception	3.39[b]	3.28[b]	3.20[b]	2.81[a]	2.70[a]	10.08	<.001	.11
Cluster variables (raw scores)								
Autonomous motivation	4.64[d]	4.77[d]	3.94[c]	2.29[b]	1.88[a]	338.61	<.001	.73
Controlled motivation	2.38[a]	3.48[c]	3.26[b]	3.73[d]	2.22[a]	239.75	<.001	.66
Distrust-based amotivation	1.89[a]	1.88[a]	2.90[b]	4.07[c]	4.19[c]	218.62	<.001	.63
Effort-based amotivation	1.15[a]	1.12[a]	2.44[c]	1.68[b]	2.21[c]	159.86	<.001	.56
Cluster variables (z-scores)								
Autonomous motivation	0.55	0.61	-0.06	-1.82	-1.40	0.55		
Controlled motivation	-0.73	0.97	0.27	-1.21	0.99	-0.73		
Distrust-based amotivation	-0.55	-0.63	0.30	1.47	1.33	-0.55		
Effort-based amotivation	-0.55	-0.55	1.29	0.90	0.22	-0.55		
Outcome								
Annual dose intention	4.36[c]	4.37[c]	3.74[b]	2.71[a]	2.89[a]	61.09	<.001	.32

Figure 1. Autonomous motivation in prediction of booster dose intention by infection history with standardized simple slope coefficients.

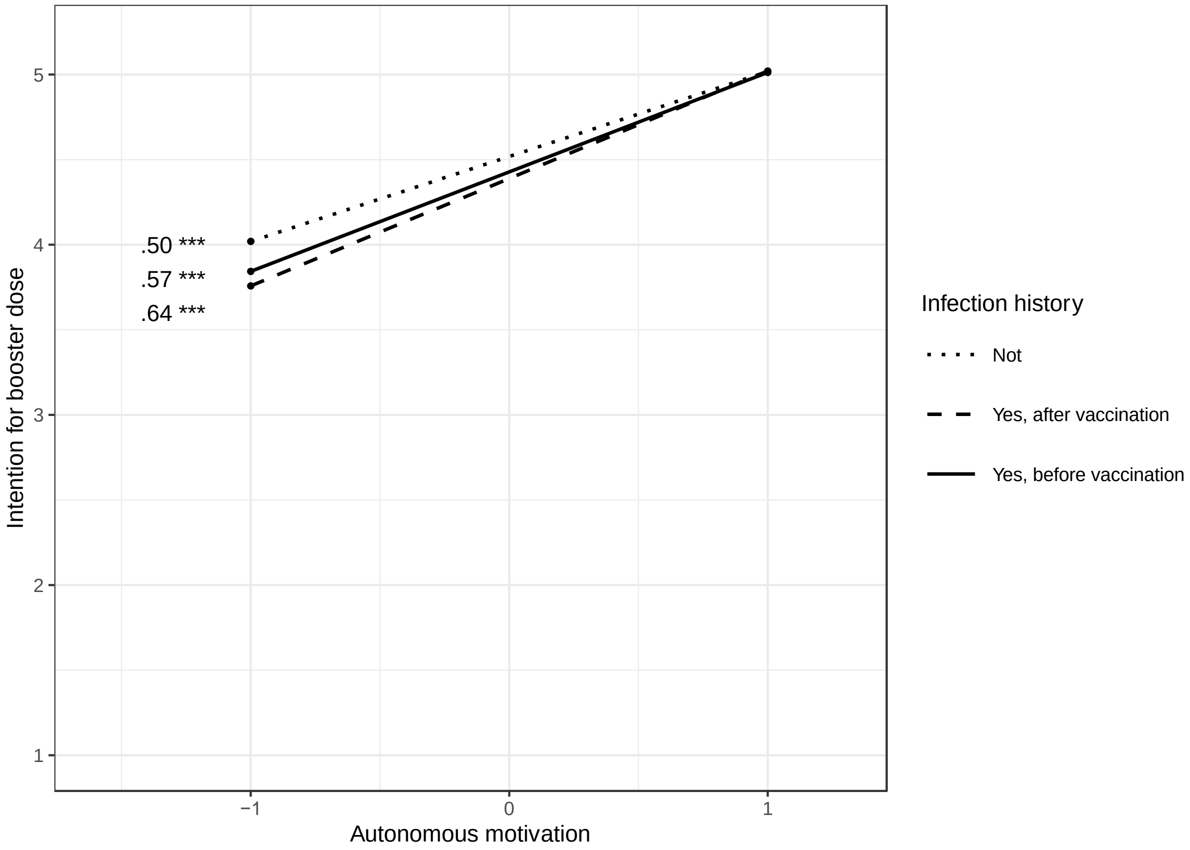
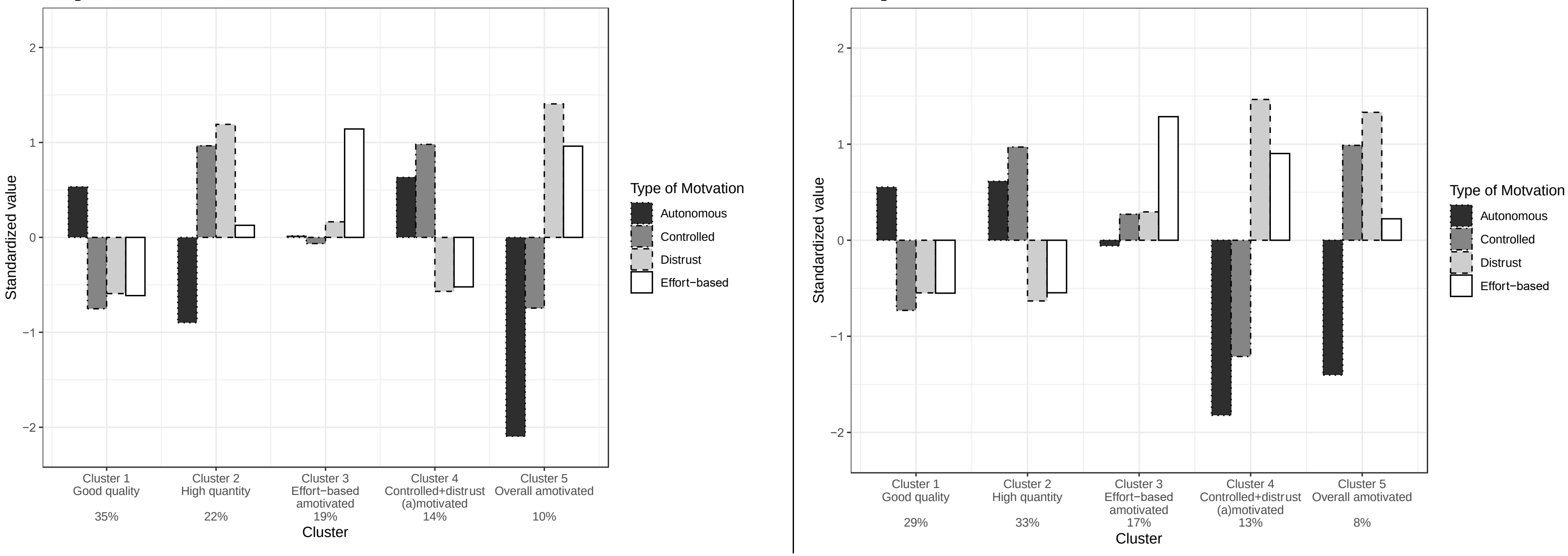


Figure 2. Visualizations of standardized cluster variables across clusters in both samples

A. Sample 1

B. Sample 2



Supplementary Materials

Table 1S. *Contingency table for clusters and gender in sample 1 (in %)*

	Gender	
Clusters	*Male*	*Female*
Good	39.4	60.6
High	42.6	57.4
Effort-based	35.1	64.9
Controlled+distrust	27.3	72.7
Amotivated	36.5	63.5
	37	63

Figure 1S. Distrust-based amotivation in prediction of the intention to have an annual dose by infection history with standardized simple slope coefficients.

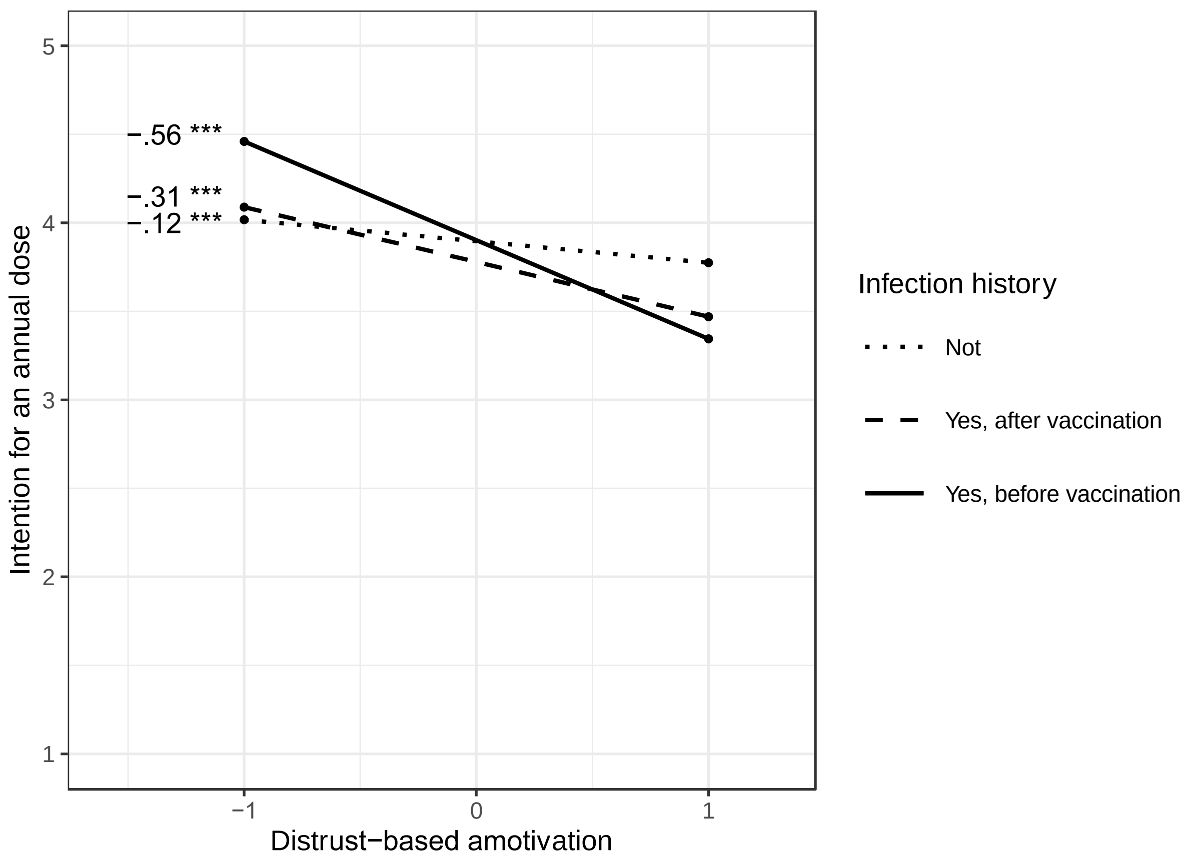


Figure 2S. Visualizations of clustering validation techniques in both samples