Risk Perception as a Motivational Resource during the COVID-19 Pandemic: The Role of Vaccination Status and Emerging Variants

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Research Article

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Posted Date: September 28th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-2069423/v1

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Abstract

Background. People's perceived risk to be infected and to have severe illness has been thought as a motivational source of adherence to behavioral measures during the COVID-19 crisis.

Methods. We used online self-reported data, spanning 20 months of the COVID-19 crisis in [blinded] (n = 241,275; 34% vaccinated; July 2020 - March 2022).

Results. The findings demonstrate, especially among vaccinated persons, that people's perceived severity was more prominent than perceived probability for infection, up until Omicron emerged. At both the between-persons and between-day levels, perceived severity was the most strongly related to autonomous motivation, a pattern that was less pronounced for unvaccinated people towards the end of the crisis.

Conclusions. These findings show that variation in risk perceptions largely accounts for the variation in both between-individuals' and day-to-day variation in motivation to adhere to the measures, thereby showing a sensitivity to the characteristics of the variants of the virus and the role of one's vaccination status.

Keywords: COVID-19, risk perception, vaccination, motivation, behavior

Motivation plays a key role during the COVID-19 pandemic to predict individuals' short- and long-term adherence to (sometimes intrusive) behavioral measures, such as wearing face masks, physical distancing and accepting a vaccine. What especially matters is that individuals' motivation is autonomous, that is when one fully endorses or internalizes the necessity of requested health behaviors (Morbée et al., 2021; Schmitz et al., 2022). Given the key role of this aspect, the question arises which factors underlie autonomous motivation.

In the present study, we focus on the role of risk perception (Qin et al., 2021), which denotes both the estimated probability of being infected by the virus and the probability of experiencing severe symptoms (e.g., Becker et al., 1977). We had two major aims. First, we wanted to examine the evolution of risk perception as a function of different phases in the pandemic and individuals' vaccination status. Second, we aimed to investigate the role of risk perception as a motivational resource, thereby examining which aspect of risk is most predictive of autonomous motivation. To examine the robustness of the risk-motivation association, we considered both the between-day and between-person levels of measurement and compared the vaccinated and unvaccinated individuals. Because experts, politicians, and media referred on a daily basis to people's health risks during the pandemic, the proposed fine-grained study on risk perception in the motivational posture of the citizens is of utmost importance to fine-tune communication to the population during the pandemic. The presented findings are part of a long-term and large-scale population study that was initiated right after the outbreak of COVID-19 in [blinded] and lasted more than 2 and a half years.

The Role of Motivation for Health Behavior

During the COVID-19 crisis, policy makers faced several motivational challenges. To avoid a steep rise in infections and an overload of healthcare services, it was of paramount importance that citizens adhered to behavioral measures to contain infections but also accepted to get vaccinated. This required the motivation of people to do so (Martela et al.,

2021). As research shows, however, not all types of motivation yield the same effects. From the perspective of Self-Determination Theory (SDT, Ryan & Deci, 2017; Ryan et al., 2021; Vansteenkiste et al., 2006), autonomous motivation, which rests on a full and voluntary endorsement of the requested health behavior, is of critical importance. When individuals are autonomously motivated, they willingly regulate their behavior out of personal conviction and meaning. For instance, they adhere to corona-safe behaviors to protect vulnerable people, to avoid overburdening the health care sector or simply to stay healthy themselves. In contrast, controlled forms of motivation take place when people feel lured, pushed, or even manipulated to perform a health behavior. Abundant research in the health domain has shown that autonomous motivation better predicts long-lasting behavior change than controlled motivation and amotivation (Ng et al., 2012). This has been documented, for example, for smoking cessation (Williams et al., 2006), weight loss (Williams et al., 1996), physical activity (Verloigne et al., 2011) and diabetes management (Senecal et al., 2000).

The COVID-19 crisis created the opportunity to test some of the basic premises of SDT at a population level and over a long period of time. The available research points to three key findings. First, the benefits of autonomous motivation emerge across different health behaviors, including both the adherence to safety measures (e.g., wearing face masks, keeping distance; Morbée et al., 2021) and the acceptance of the vaccine (Schmitz et al., 2022, Van Oost et al., 2022). Second, these benefits are not just short-lived. Indeed, autonomous motivation relates to both concurrent and long-term desirable outcomes, including a lower likelihood of infection (Waterschoot et al., 2022) and the acceptance of a booster vaccine (Waterschoot, Van Oost et al., 2022). Third, the beneficial role of autonomous motivation materializes at both the between-person and between-day level. As an example of the latter, the day-to-day variability in the autonomous motivation of the population was related to lower infection and hospitalization rates, respectively, 4 and 6

weeks later (Waterschoot et al., 2022). Overall, these findings confirm that the benefits of autonomous motivation are wide-ranging, long-lasting, and robust.

Risk Perception as a Motivational Resource

One critical source of autonomous motivation concerns individuals' risk perception (e.g., Qin et al., 2021). Within health-specific behavioral theories, like the health belief model (Becker et al., 1977) and the health action process approach (Schwarzer & Hamilaton, 2020), risk perception refers to a host of cognitive and affective processes that result in a predictive judgment of the infectious nature of the virus along with its associated consequences (Ferrer & Klein, 2015). In these models, risk perception involves two aspects, that is, the probability of being infected by the virus (i.e., personal vulnerability, infection probability) and the perceived severity of the symptoms after actual infection (i.e., severity). Both aspects can be estimated with respect to one's own situation and the population at large. It should be emphasized that risk denotes a *subjective* assessment which can differ between persons and days and can also differ from the actual risk (Ganzach et al., 2008). Indeed, regardless of its link with reality, it is the perceived risk that carries the greatest predictive validity for people's emotional, motivational, and behavioral functioning (e.g., Betsch et al., 2015).

People's risk perception has generally been found to be an important predictor of health behavior. Risk perception feeds into motivation to change, with action planning and coping planning contributing to translation into actual behavior (e.g., Schwarzer & Hamilton, 2020). Indeed, several studies demonstrated positive associations between levels of risk perception and levels of adherence to (governmental-imposed) preventive measures (e.g., Wise et al., 2020). In the present study, we aimed to expand this growing body of evidence by conducting a systematic investigation of the risk perception-motivation link. Wise et al. (2020) provided some preliminary evidence for this association by showing that individuals who perceived higher risks for themselves or for the population also found it more valuable

and meaningful to conform to the recommended safety measures. Risk perception was also found to relate positively to individuals' autonomous motivation to accept vaccination and to higher actual vaccination intentions (Schmitz et al., 2022). At the same time, few studies (Wolff et al., 2019) examined whether the probability or severity perception yielded the strongest association with health-protective behavior. Moreover, we sought to examine whether day-to-day variation in risk would explain day-to-day variation in motivation. By including both issues, our findings are likely to be of great interest from a public health perspective.

Role of the Evolution of the Crisis and Vaccination Status

Few studies focused on context-determined variation of risk perception within persons. For instance, Wise et al., (2020) longitudinally showed increases in perceived risk across a period of increasing infection numbers. Along similar lines, Abir et al. (2020) found decreasing levels of perceived risk after the start of a lockdown. Also, levels of risk perception decreased as the crisis unfolded, probably because people appraised the virus to be less novel and less unpredictibale (Fischhoff, 2020). However, the literature remains scarce and, as of today, no studies assessed in a more direct manner crisis-related evolutions in risk perception and their relationship with motivation.

Another problem in the management of the pandemic was to overcome vaccine hesitancy and the tendency to delay or refuse vaccines despite their availability (WHO, 2014). A variety of factors has been shown to influence willingness to accept a vaccine, such as knowledge, perceived benefits of vaccination, perceived behavioral control, trust in authorities or limited side effects (e.g., Chen et al., 2021; Morbée et al., 2022; Schmitz et al., 2022; Van Oost et al., 2022). Those people who more strongly believed that they could be facing severe symptoms in case of infection also reported a higher vaccination intention (e.g., Qin et al., 2022; Tu et al., 2022; Wang et al., 2020). Compared to the perceived probability,

the perceived severity aspect of risk perception showed stronger associations with vaccination intentions (Caserotti et al., 2021; Chen et al., 2021; Hilverda & Vollmann, 2021). In addition, higher levels of risk perception were related to higher autonomous motivation to get the vaccine, which in turn resulted in a higher vaccination acceptance and, eventually, vaccination uptake (Schmitz et al., 2021; Van Oost et al., 2022). However, it should be noted that these studies were mainly conducted before or at the beginning of the vaccination rollout, whereas no studies were conducted later into the pandemic when those being unvaccinated became fewer and more homogeneous as a group.

The Present Study

In the present study, we pursued an in-depth investigation of the evolution and role of risk perception as a predictor of motivation throughout the pandemic. Figure 1 provides an overview of the conceptual model. We monitored motivation and adherence during 20 months of the COVID-19 pandemic starting in July 2020. During this period, we also measured risk perception, distinguishing between perceived probability of infection and perceived severity. Our large dataset allowed us to pursue both a descriptive aim (i.e., examining variations in risk perception in different phases of the pandemic) and a structural aim (i.e., examining the role of risk perception as a predictor of motivation). Specifically, we formulated three research questions and associated hypotheses.

First, we examined whether risk perception varied as a function of emerging variants and individuals' vaccination status. Although both aspects of risk were expected to evolve in parallel throughout most of the pandemic, we expected that the emergence of the highly contagious, yet less severe Omicron variant in the fall of 2021 may have led to an asymmetrical evolution, with probability of infection increasing and the perceived severity of illness decreasing at that moment (CDC, 2022). Specifically, we predicted a main effect of time and a lower correlation between both aspects of risk as Omicron became more prevalent

(Hypothesis 1a). Further, we hypothesized that the difference between vaccinated and unvaccinated persons would increase across time because the group of unvaccinated persons would become increasingly more homogeneous (Hypothesis 1b). The reason is that in the spring and summer of 2021 the group of unvaccinated persons comprised a mix of uninvited, doubting, and refusing individuals, but this heterogeneity decreased as the vaccination campaign unfolded, with the group of unvaccinated becoming more homogeneously against vaccination by the end of 2021.

Second, we examined the unique predictive power of both aspects of risk in the prediction of autonomous motivation. We hypothesized that the severity of the infection would be more critical than the probability in predicting a stronger endorsement of and willingness to adhere to the measures (Hypothesis 2). In a more exploratory way, we examined whether the risk-motivation association depended on the specific variant (i.e., Omicron) and the individuals' vaccination status. We were interested to check whether unvaccinated persons may not only perceive fewer risks, but also be less responsive to the risk perception-motivation link. Similarly, as the Omicron variant was accompanied by less severity, the motivating potential of this aspect of risk may decrease as well.

Third, the availability of data on risk perception, motivation, and adherence daily provided a unique opportunity to examine the sequential model in Figure 1 on a day-to-day basis rather than on a between-person level, as was the case for our second research question (above). In doing so, we included the objective registration of daily hospitalizations as a predictor of daily risk perception. We hypothesized that participants would report higher risk and higher risk for severe illness on days with a higher record of hospitalizations. Perceived severity would then be related to higher adherence to health behaviors via autonomous motivation (Hypothesis 3).

Methods

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 well-being, risk perception, motivation, adherence to the COVID-19 measures. This survey was distributed online through advertisements on social media and national newspapers. After an introduction about the content of the research project, participants had to complete an informed consent explaining that their participation was voluntarily, that data would be analyzed anonymously, and that they could end their participation anytime without consequences. In addition, we provided contact information in case of questions or negative feelings. The project was approved by the ethical committee of [blinded] (N° 2020/37).

The study took place between July 2020 and March 2022. Across 580 days of the crisis (68% with $n > 40$), 241,275 participants completed the survey ($M_{age} = 49.17$, range = 18 – 82; 66.6% female; 34% vaccinated participants). From this sample, 81.7% reported no comorbidity factor, 15.3% reported only one and 3% reported to have more than one comorbidity.

Measures

Prior to measuring the psychological variables, we asked for people's age, gender (i.e., male or female), vaccination status (i.e., vaccinated or not vaccinated), number of comorbidities (i.e., respiratory condition, diabetes, heart disease or hypertension, lung disease, liver disease, cancer, disease affecting the immune system, and a disease not specified in this list), and education level (i.e., no graduation or secondary graduation, Bachelor degree or Master degree).

Risk Perception. We measured risk perception using four items (Wolff et al., 2019). Two items assessed participants' estimated probability to be infected by the coronavirus in

the near future (1 = 'Very small' to 5 = 'Very big'; r=.42, $p<.001$) and two items assessed participants' estimated severity of the symptoms when being infected (1 = 'Not at all serious to 5 = 'Very serious'; r=.63, $p<.001$). They answered both questions twice, once with respect to themselves and once with respect to the [blinded] population.

Autonomous Motivation. We assessed people's motivation to adhere to the corona safety measures with an adapted version of the Behavioral Regulation in Sport Questionnaire (Lonsdale et al., 2008). After the stem "Over the past week, I've adhered to these measures because", people answered four items for autonomous motivation on a 5-point scale ranging from 1 (not at all true) to 5 (totally true). Two item examples are "... because I find it personally relevant" and "because these are an expression of my personal values" (α = .90).

Adherence to the Measures. We tapped people's self-reported adherence with one item for each of the three most important and stable COVID-19 measures introduced in [blinded] across the current period, that is, "to wash your hands frequently", "to wear your face mask when mandatory or recommended", and "to maintain physical distance from others." Participants were asked to indicate on a scale ranging from 1 ("I do not adhere to it at all") to 5 ("I totally adhere to it") the extent to which they followed each of the three measures (α = .73).

Hospitalizations. We obtained data on hospitalizations from Sciensano, the national public health institute (Sciensano, 2022). As this is a parameter expressed in exponentials, we applied a log-transformation to include this variable in linear analyses. The hospitalization numbers relied on the same data collection protocol throughout the period covered in our study.

Analysis Plan

Before conducting the analyses, we subdivided the total period into pandemic-related phases. We determined these phases as shown in Figure 2. Herein, the upper two figures

showing the mean evolution of both risk perception aspects across months (lines) and phases (bars) for both groups of vaccinated and unvaccinated participants. The middle figure shows the proportion of COVID-19 variants with the number of hospitalizations, while the bottom figure shows the national proportion of vaccinated people with the proportion of vaccinated participants in the current sample. Based on the described information in these figures, we subdivided the total period into six phases.

To examine the mean levels of risk perception aspects across the pandemic (in days), thereby investigating the differences between vaccinated and unvaccinated participants (Research Question 1), we performed a Multivariate Analysis of Variance (MANOVA) including the interaction between phases and vaccination status. We controlled for background variables age, gender, and comorbidity and excluded the phases *Summer 2020* and *Second wave* as the number of vaccinated participants was insufficient on these moments. Across the analyses, categorical variables (i.e., vaccination status, phases) were dummy coded, using the status of *non-vaccination* and phase *Omicron* as reference levels.

Next to this descriptive approach, we investigated structural associations on a between-person and between-day level, respectively examining research questions 2 and 3. The use of such multilevel approach was justified by calculating the Intra-Class Coefficient (ICC), representing the similarity of participants within days (i.e., between-days variance). As preliminary analyses, we assessed Pearson correlations on both levels for continuous variables and assessed the role of categorical background variables in the study variables using MANOVA for multivariate effects and ANOVA's for univariates effects.

To investigate the role of vaccination status, both aspects of risk perception and their associations across phases in prediction of autonomous motivation, including two- and three-way interaction terms, we performed a linear mixed regression model in a subset of the total dataset (i.e., from phase *Alpha* onwards to have a sufficient number of vaccinated

participants). When doing this, we included *days* as a random intercept, thereby accounting for the between-days variance. Indeed, there could be meaningful variance at the between-day level. Accounting for the nested structure of the data avoids biased parameter estimates (Wilms et al., 2020). Also, we included both aspects simultaneously into the model, allowing us to examine their unique predictive validity towards autonomous motivation. We centred both continuous variables. We checked the model assumptions (i.e., normality of residuals, influential observations) and the level of multicollinearity by calculating the Variance Inflation Factor (VIF > 4 indicates multicollinearity).

Next to between-person associations, we examined the extent to which risk perception would yield a motivating effect on a daily level. To do this, we performed a Multilevel Structural Equation Model (MSEM) using the R-package lavaan (Rosseel, 2021) in which we built a sequence of both aspects of risk perception to autonomous motivation to behavioral adherence. To secure a fine-grained picture of how the evolution of the crisis impacts risk perception, we modelled the log transformed number of hospitalizations as an additional predictor in the sequence.

We report how we determined our sample size, all data exclusions (if any), and all sanitary behaviors in the study, and we follow JARS (Kazak, 2018). All data, analysis code, and research materials are available at https://osf.io/5cqhr/?view_only=833b72b610b249a8a402fd5b58529582. We analyzed the data using R, version 4.1.2 (R Core Team, 2021).

Results

Research Question 1: Mean Level Differences in Risk Perception

The MANOVA proved significant (Wilks' lambda=.95, $F(2, 156{,}578) = 3793.2$, $p < .001$). Considering each outcome separately, we found main effects for, respectively, phases and vaccination status in the prediction of both perceived infection ($F(3, 12{,}415) = 4245.5$, p

304 < .001, η_p^2 = .03; F(1, 3364) = 3450.6, p < .001, η_p^2 = .16) and severity (F(3, 14679) = 5881,
305 p < .001, η_p^2 = .01; F(1, 8427) = 10,128.61, p < .001, η_p^2 = .07). Also, vaccination status and
306 phases interacted significantly for both perceived infection (F(3, 3840) = 1313.1, p < .001,
307 η_p^2 = .04) and perceived severity (F(3, 2196) = 879.69, p < .001, η_p^2 = .02). The output is
308 visualized in Figure 2 (2 top panels), adding the mean levels of both aspects in phases
309 *Summer 2020* and *Second wave* for the sake of clarity.
310 It can be clearly noticed that the levels of both perceived infection and perceived
311 severity show a steady decrease across phases in the group of unvaccinated participants,
312 although perceived infection increased again in phase *Omicron*. As a second finding, the
313 main differences between those being vaccinated and unvaccinated appeared significant. For
314 perceived infection risk, both groups show a similar pattern in phases *Alpha* and *Summer*
315 *2021*, while the levels in phases *Delta* and *Omicron* show a strong increase among vaccinated
316 participants only. For perceived severity, the differences between vaccinated and
317 unvaccinated can be noticed much earlier with vaccinated participants only starting to show
318 lower levels of perceived severity from phase *Delta*.
319 These findings indicate that both aspects of risk perception are differentially
320 associated across phases. Indeed, when conducting a linear regression model, using *severity*
321 as a criterion and infection (centered), vaccination status (with unvaccinated as the reference
322 level) and phases (with phase *Omicron* as the reference level in the dummy codings) along
323 with all their interactions as predictors, we found a highly significant two-way interaction
324 between infection and the phases (see Table S2). As Figure S1 shows, the association
325 between infection and severity is similar in phases *Alpha* to *Delta*, with even stronger
326 associations in the latter two, whereas phase *Omicron* shows a noticeably weaker association.
327 **Research Question 2: Predictive Validity of Risk Perception**

First, preliminary analyses showed significant multivariate effects for gender (Wilk's lambda = .96, $F(4, 107667) = 1008.23$, $p < .001$), comorbidity (Wilk's lambda = .93, $F(8, 216102) = 940.57$, $p < .001$) and education level (Wilk's lambda = .97, $F(12, 277952) = 274.76$, $p < .001$). Table S1 shows univariate analyses with effect sizes, revealing higher levels of risk perception aspects, autonomous motivation, and adherence for female and those having more comorbidities.

Table 1 shows ICC values lower than .20, indicating that most of the variance is located at the within-days or at the between-person level. Therefore, we computed Pearson correlations and descriptive statistics on both the between-persons (i.e., upper triangle) and the between-days levels (i.e., lower triangle). The patterns of correlations were quite similar at both levels and all associations were positive. Specifically, both aspects of risk perception were positively correlated with autonomous motivation and behavioral adherence. Further, at the between-day level, the variation in registered hospitalizations across days related positively to autonomous motivation and adherence. At the between-person level, age related positively to concerns, risk perception, autonomous motivation, and adherence.

The output (Table 2) shows strong main effects for vaccination status and both aspects of risk perception, with the largest effect size for perceived severity. Additionally, we found significant two-way interactions, confirming the presence of a stronger association between perceived severity and autonomous motivation for those being vaccinated. The significant three-way interactions confirm the moderating role of phases in this association, a pattern that did not emerge for perceived probability. We visualized these effects in Figure 3.

As can be seen, the relation of perceived probability with motivation is rather modest, certainly in comparison with the relation of perceived severity with motivation. Also, the difference between vaccinated and unvaccinated participants did not change much across phases. For perceived severity, it is interesting to note, first, stronger associations for those

being unvaccinated in phases *Alpha* and *Summer 2021*, while this is reversed for phases *Delta* and *Omicron*. Even in the final phase, the association for those being unvaccinated seems to weaken compared to the other phases. This finding might be since the group of unvaccinated participants in phases *Alpha* and *Summer 2021* were still a mixed group including people waiting to be vaccinated but who did not have the chance yet, while in phases *Delta* and *Omicron* unvaccinated people were more homogeneously refusing the vaccine.

Research Question 3: Risk perception as a Motivational Source on a Daily level

Figure 4 shows the output and fit indices of the MSEM with standardized coefficients on between-days level. First, perceived severity emerges as the strongest predictor of adherence through autonomous motivation ($\beta_{indirect} = .42$, $p < .001$), while the indirect effect for perceived probability does not even reach significance ($\beta_{indirect} = .02$, $p = .12$), essentially because this variable fails to predict autonomous motivation when controlling for perceived severity. Of note, a significant positive coefficient between perceived severity and adherence remains after including autonomous motivation as a mediating variable. Next, the variation in hospitalization numbers across days is related positively with both aspects of risk perception, autonomous motivation, and adherence, although the strongest relation can be found with perceived severity. The significant indirect effect ($\beta_{indirect} = .27$, $p < .001$) indicates that numbers of hospitalizations are positively related to adherence via daily levels of perceived severity and autonomous motivation. Such a pathway was not found for perceived probability ($\beta_{indirect} = .01$, $p = .27$).

Discussion

The present large-scale study provides a unique and fine-grained insight into the evolution and role of risk perception during the COVID-19 pandemic. Prior research indicated fairly large individual differences in people's estimated risks, which explain variability in one's (intentions to) adherence to the sanitary measures (Savadori & Laurola,

2022; Schwarzer & Hamilton, 2020), autonomous motivation for vaccination (Schmitz et al., 2022) and intention to take the vaccine (Tu et al., 2022; Schmitz et al., 2022). We replicate and extend this body of work by monitoring individuals' perceived risk for 20 months (i.e., descriptive aim) and examining which facet of risk perception (i.e., probability of infection or severity) yielded the strongest motivational effect (i.e., structural aim), an issue explored at both the between-person and between-day level. In addressing both aims, we considered the role of vaccination status and the phase of the pandemic. The data allowed us to highlight four key findings.

First, the perceived severity of symptoms after infection was a more prominent and impactful aspect of risk than the perceived probability of becoming infected throughout the pandemic until Omicron emerged. At that point, the more contagious yet less sick-making character of Omicron also became apparent in individuals' risk perception. This was also the point in time when both facets of risk started to evolve in an asymmetrical rather than parallel way.

Second, individuals' vaccination status was related to perceived risk, a finding that was in line with earlier literature (e.g., Tu et al., 2022). Yet, the timeframe of the current dataset allowed us to notice a widening difference between vaccinated and unvaccinated across time. Presumably, in the early months of the vaccination campaign, unvaccinated individuals represented a more heterogeneous group, with the groups becoming increasingly homogeneous as the pandemic evolved. Especially the unvaccinated group gradually consisted more and more of people who explicitly refused the vaccine. Interestingly, the vaccinated people still perceived higher risks than unvaccinated, a finding also reported by Qin et al. (2022). Several reasons may account for these mean-level differences. Unvaccinated persons may adjust their behavior to minimize risks (e.g., avoiding close contacts) or they may follow different types of media than vaccinated persons do (e.g., Puri et

al., 2020). From another perspective, those being unvaccinated might indeed experience decreasing levels of risk perception across time. However, only future longitudinal research could chart such evolutions across time within the same group of unvaccinated participants.

Third, as hypothesized, only the severity aspect of risk related to individuals' autonomous motivation to adhere to the measures. As can be noticed in Figure 3, each of the associations between perceived severity and autonomous motivation was significant and positive across the four phases of the pandemic. Also, this association applied to vaccinated and unvaccinated individuals, with the strength of the association becoming somewhat less strong among the unvaccinated as the less severe but more contagious Omicron variant became more prevalent. The changing composition of the unvaccinated group may be responsible for this shifting association and signal that unvaccinated – apart from perceiving fewer risks – are also somewhat less responsive to the risk-motivation link. That is, perceived severity served somewhat less as a motivational impetus.

Fourth, the critical role of severity was also documented at the between-day level. That is, on days when the population reported higher risks, they were more autonomously motivated, which in turn explains their higher adherence to the prevailing corona-measures at that moment. Interestingly, objectively registered hospitalizations on a given day were positively related to both aspects of risk, possibly serving as an antecedent of perceived risk.

In practice, policy makers and governments could learn from these results, thereby raising the question how to support people's autonomous motivation through risk perception. Rather than inducing anxiety, information could be provided in a transparent and clear way, doing this to nurture people's perception to be at risk for infection at particular phases of the crisis. Such information goes along with meaningful rationales why the intrusive sanitary behaviors should be performed, what the consequences could contain for an overload of hospitalizations and why the performance of such behavior could be protective for the health

for oneself and others. Strategies like 'if-then' scenarios could provide such information where prospective of the infection curves are illustrated what could happen when the level of behavioral adherence is low, for instance (Petersen et al., 2021).

Of course, the current research contains several limitations that should be discussed. As a first, the current sample may have suffered from some degree of self-selection and was not representative of the [blinded] population.

Second, the present study did not include data before July 2020 because it was not included in the questionnaire then. This is unfortunate as the first months of the pandemic were indeed characterized by high levels of unpredictability of the COVID-19 virus.

Third, the current study only focuses on two aspects of risk perception, while also other aspects could have been included, such as emotional risk perception (e.g., the extent to which the risk make people feel dread; Slovic, 2000).

Conclusion

Motivation played a key role in the COVID-19 pandemic, with autonomous reasons leading to a better adherence of sanitary behaviors. In the present study, we examined the role risk perception, with especially perceived severity, as a source of people's autonomous motivation. Using data being collected across 20 months, we were allowed to focus on the role of vaccination status and phases in the pandemic, thereby demonstrating those being vaccinated showing stronger differences with those being unvaccinated, thereby having higher levels of risk perception. Also, the emergence of different COVID-19 variants played a significant role in people's risk perception, with especially Omicron having a different psychological impact. From both the theoretical and practical point of view, we could learn from these results with, firstly, people's risk perception as a fundamental antecedent of their reasons to perform sanitary behavior and, secondly, how both personal and contextual factors

452 could intervene with people's psychological functioning, both on a between-persons and
453 between-days level.

454 **List of abbreviations**

455 - COVID-19 = Coronavirus Disease 2019
456 - SDT = Self-Determination Theory
457 - (M)ANOVA = (Multivariate) Analysis of Variance
458 - VIF = Variance Inflation Factor
459 - MSEM = Multilevel Structural Equation Model

460 **Declarations**

461 **Ethics approval and consent to participate**

462 The project was approved by the ethical committee of Ghent University, Belgium (N°
463 2020/37). Informed consent was obtained from all the participants. All methods/protocols
464 were performed in accordance with the relevant guidelines and regulations.

465

466 **Consent for publication**

467 Not applicable

468

469 **Availability of data and materials**

470 The R scripts to carry out the analyses are publicly available on Open Science Framework:
471 https://osf.io/5cqhr/?view_only=833b72b610b249a8a402fd5b58529582 . Datasets are hosted in
472 Zenodo (a public repository) and are available upon request and for replication purposes only (after
473 contacting responsible researcher)

474

475 **Competing interests**

476 The authors declare that they have no personal or financial conflict of interest that could have
477 influenced the work reported in this paper.

478

479 **Funding**

480 The present research was financially supported by the [blinded] Federal Ministry of Health through
481 RIZIV (Rijksinstituut voor ziekte- en invaliditeitsverzekering) / INAMI (institut national de maladie-
482 invalidité).

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Authors' contributions

JW conducted conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Visualization, Writing—original draft, Writing—review and editing. MV conducted Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing—original draft, Writing—review and editing. VY conducted Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Writing—review and editing. SM conducted Conceptualization, Data curation, Investigation, Methodology, Writing—original draft, Writing—review and editing. OK conducted Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Writing—review and editing. OL conducted Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Validation, Writing—review and editing. MS conducted Conceptualization, Writing—original draft, Writing—review and editing. PVO conducted Conceptualization, Writing—original draft, Writing—review and editing. ER conducted Conceptualization, Writing—original draft, Writing—review and editing. MB conducted Conceptualization, Writing—original draft, Writing—review and editing. OVB conducted Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing—original draft, Writing—review and editing.

Acknowledgements

The Motivation Barometer was initiated by [blinded] during the first lockdown with scholars from the [blinded], [blinded] and [blinded] joining the project along the way. Throughout the course of the pandemic, data collection was made possible from [blinded] and the Ministry of Health to the consortium of universities. The Ethics Committee of [blinded] approved the project.

Footnotes

Not applicable

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679 **Tables**

680 Table 1. *Multilevel Pearson correlations at the between-day level (below the diagonal) and*

681 *the between-person level (above the diagonal) with descriptive statistics and ICC's*

Variable	*M*	*SD*	ICC	1.	2.	3.	4.	5.
1. Perceived infection	3.01	0.79	.06		.48***	.37***	.31***	-.01
2. Perceived severity	3.10	0.92	.20	.68***		.61***	.50***	.30***
3. Autonomous motivation	3.49	1.21	.08	.63***	.26***		.65***	.24***
4. Adherence	4.22	0.85	.04	.58***	.31***	.86***		.17***
5. Age	49.43	14.33	.14	.14	.19*	.09	.09	
6. Hospitalizations	7.57	0.81	-	.01	.13	.24***	.35***	-.08

682 *Note. * p <.05, ** p<.01, ***p<.001. The lower triangle represents between-days*
683 *correlations; The upper triangle represents between-participants correlations.*
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Table 2. *Output of linear mixed regression model with standardized coefficients (with partial eta-squared values)*

Predictors	*Autonomous motivation*
Fixed effects	
Covariates	
Age	.10 (.02) ***
Gender	.05 (.01) ***
Education [Bachelor]	.02 (.01) ***
Education [Master]	.06 ***
Comorbidity [one]	.05 .01) ***
Comorbidity [zero]	.00
Main effects	
Perceived infection	.06 (.01) ***
Vaccination status [not vaccinated]	.29 (.03) ***
Phase [*Alpha*]	.09 (.24) ***
Phase [*Summer 2021*]	.05 ***
Phase [*Delta*]	.02 **
Perceived severity	.48 (.12) ***
Two-way interactions	
Perceived infection * Vaccination status	.00 (.00)
Perceived severity * Vaccination status	.05 (.02) ***
Perceived infection * Phase [*Alpha*]	.04 (.02) ***
Perceived infection * Phase [*Summer 2021*]	.02 ***
Perceived infection * Phase [*Delta*]	.02 ***
Vaccination status * Phase [*Alpha*]	-.08 (.01) ***
Vaccination status * Phase [*Summer 2021*]	-.03 ***
Vaccination status * Phase [*Delta*]	.00
Perceived severity * Phase [*Alpha*]	-.01 (.00) *
Perceived severity * Phase [*Summer 2021*]	.00
Perceived severity * Phase [*Delta*]	.01 *
Three-way interactions	
Perceived infection * Vaccination status * Phase [*Alpha*]	.00 (.00)
Perceived infection * Vaccination status * Phase [*Summer 2021*]	.00
Perceived infection * Vaccination status * Phase [*Delta*]	.01 ***
Perceived severity * Vaccination status * Phase [*Alpha*]	-.07 (.02) ***
Perceived severity * Vaccination status * Phase [*Summer 2021*]	-.05 ***
Perceived severity * Vaccination status * Phase [*Delta*]	-.01 **
Random Effects	
σ^2	.86
τ_{00}	.03
Marginal R^2 / Conditional R^2	.42 / .45

Note. * *p*<.05, ** *p*<.01, *** *p*<.001; *In the dummy codings, phase Omicron and unvaccinated are assigned as reference level.*

690 **Figures**

691 *Figure 1*. Conceptual model of the current research with descriptived research questions.

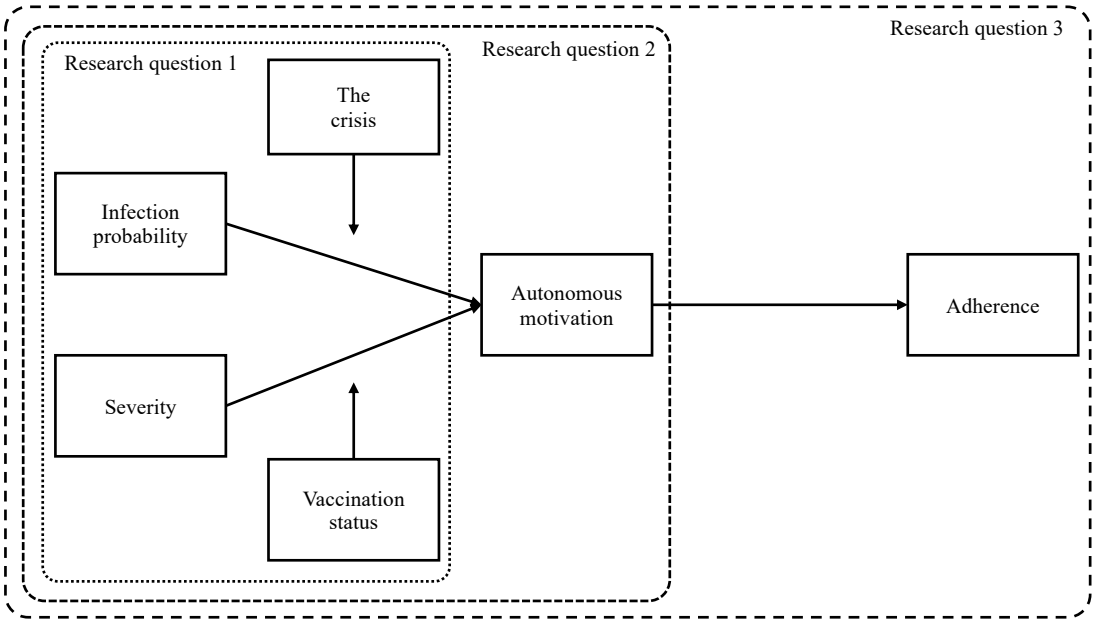

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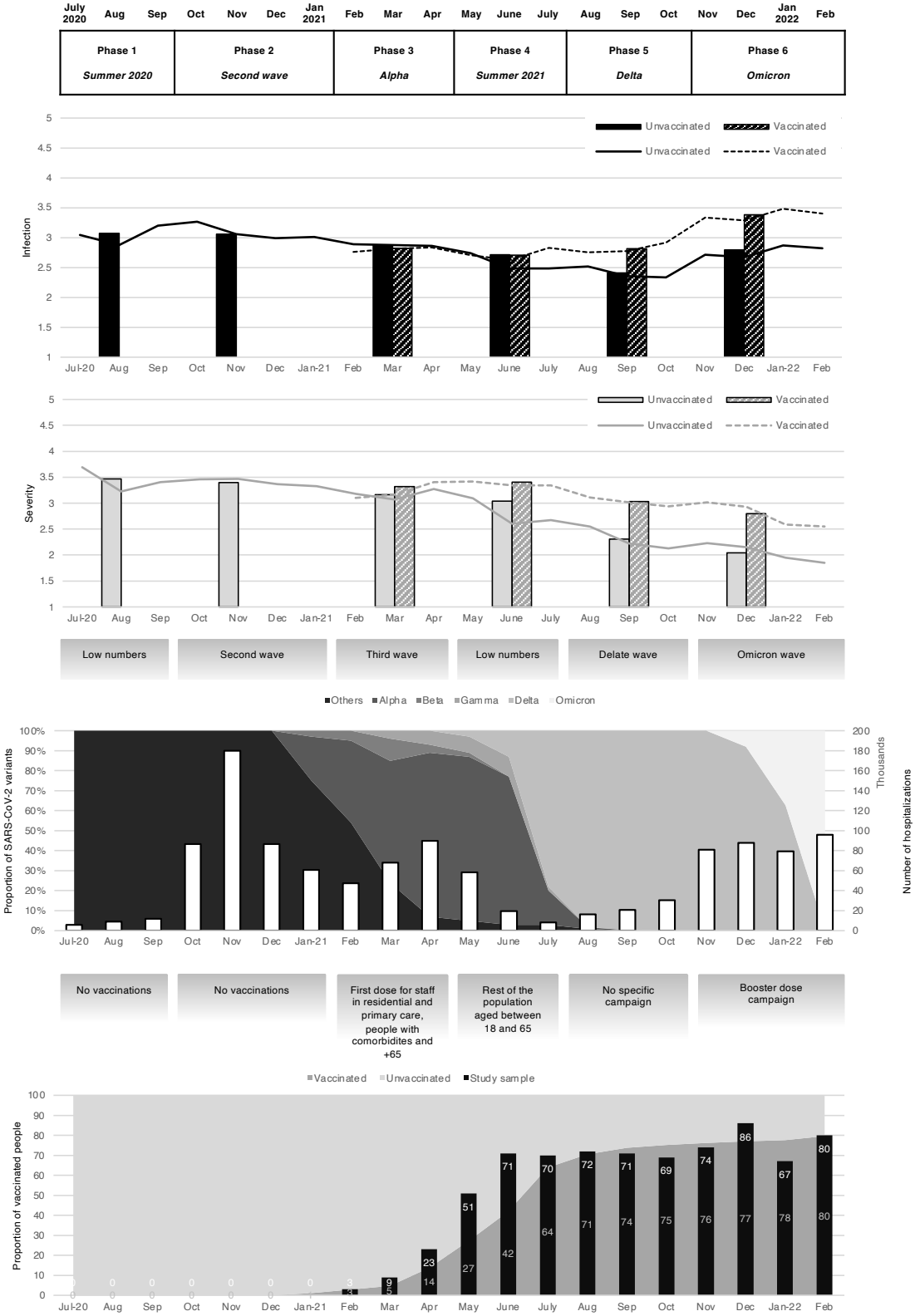
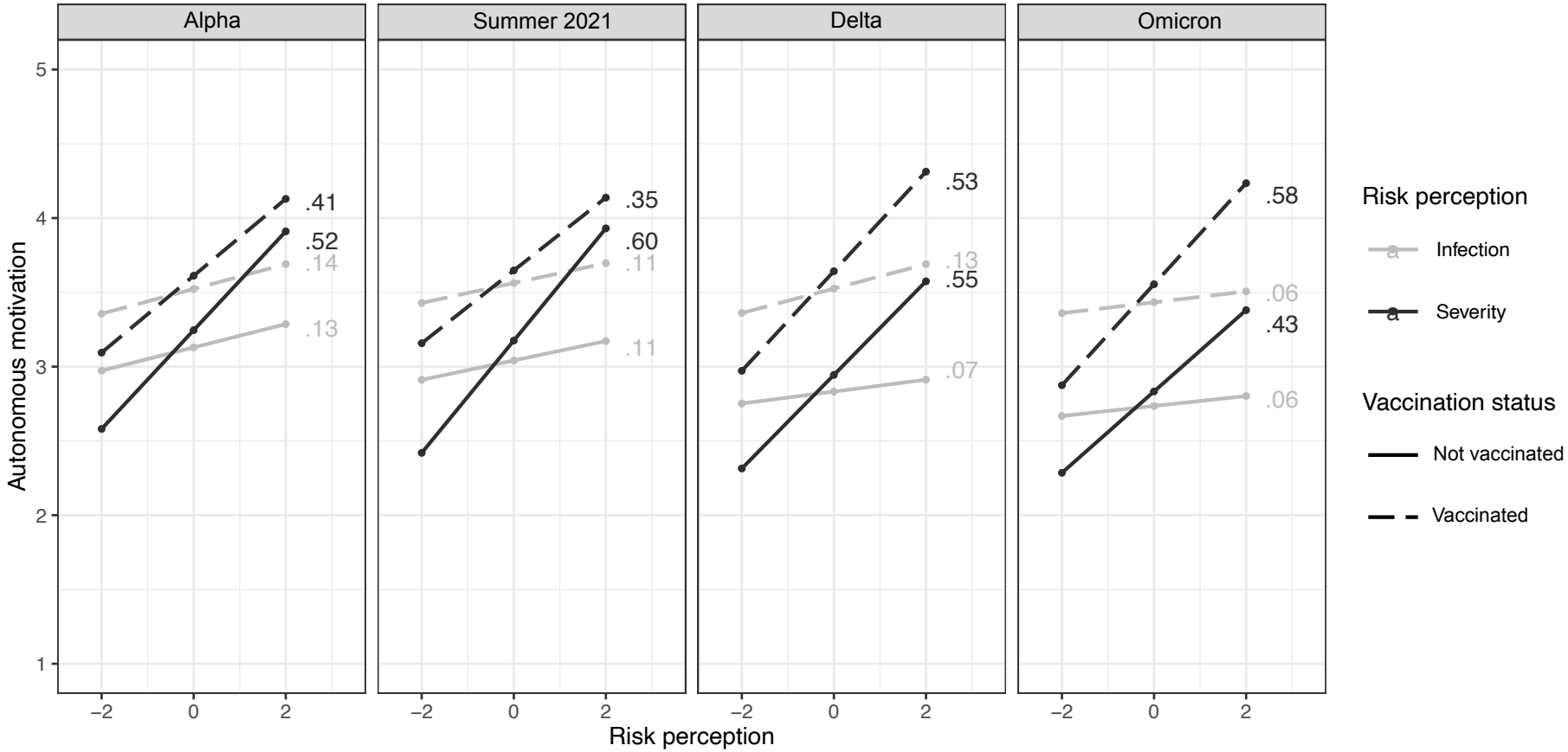
Figure 2. Timeline of both risk perception aspects (top), COVID-19 variants with hospitalizations (middle) and percentage of vaccinated participants in comparison to the population (bottom) across months and phases.



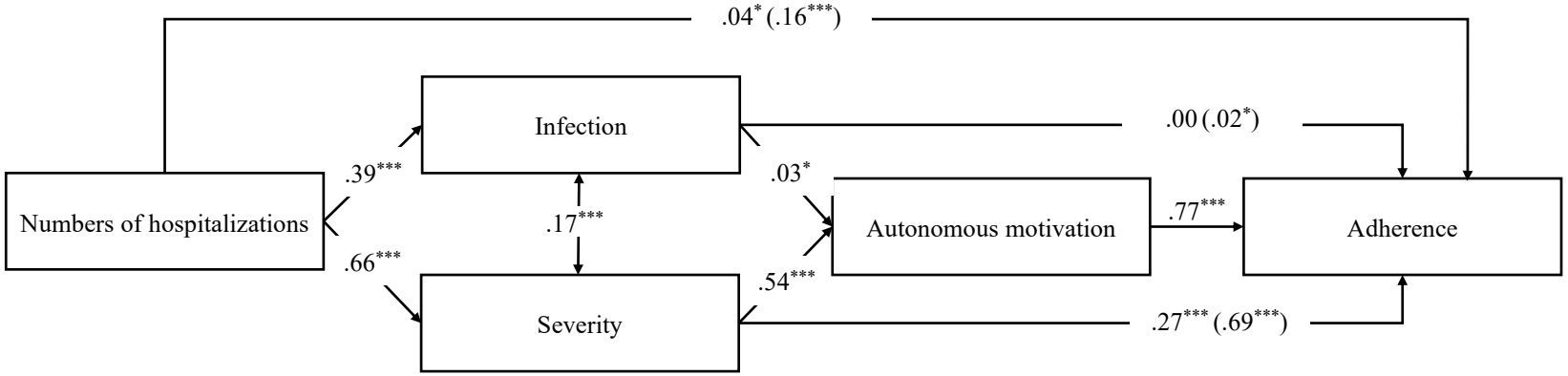
Note. Source: GISAID, via CoVariants.org; Initially, the project started from the start of the COVID-19 pandemic in March 2020. However, we only included measurements for risk perception from July 2020 on.

Figure 3. Visualization of four-way and three-way interactions in prediction of autonomous motivation with standardized simple slope coefficients.



Note. All standardized simple slope coefficients were significant with $p < .01$

Figure 4. Visualization of a MSEM with standardized coefficients on the between-days level.



$\chi^2(1) = 64.12$, $p < .001$; CFI = .99; TLI = .99; RMSEA = .02; SRMR = .01

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

Supplementary Files

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