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RISK-TAKING AND DECISION-MAKING UNDER UNCERTAINTY IN THE COVID-19 VACCINE. DOES THE SOMATIC MARKER HYPOTHESIS EXPLAIN VACCINE HESITANCY?

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SUMMARY

Background: The study aims to compare the decision-making processes of individuals with and without the Covid-19 vaccine under uncertainty.

Material/ Methods: The study included 70 participants vaccinated against Covid-19 and 70 not-vaccinated against Covid-19, matched by age, gender, and education level. Sociodemographic Data Form, Beck Depression Inventory (BDI), Beck Anxiety Inventory (BAI), Barratt Impulsivity Scale Short Form (BIS-11-SF), The Scale of Vaccine Hesitancy (SVH), and Iowa Gambling Task (IGT) were administered to the participants.

Results: A statistically significant difference was found between the vaccinated and non-vaccinated groups regarding SVH sub-dimensions and the total score ($p<0.001$). A statistically significant difference was observed between the groups in the IGT-5 sub-dimension ($p <0.05$). Although there was no statistically significant difference in IGT-total and other sub-dimensions, it was recognized that not-vaccinated participants made more choices for risky decks. A statistically significant negative correlation was found between IGT-5 and the benefit and protective value of the vaccine, solutions for non-vaccination, and SVH-total score. Besides, there was a statistically significant negative correlation between the IGT-Total score and the sub-dimension of solutions for non-vaccination.

Conclusions: The non-vaccinated group made more choices from the disadvantageous and risky decks in the long run during the decision-making task under uncertainty; they were prone to take more risks. That is why the impact of implicit and emotional processes should be considered in the risk assessment against vaccine hesitancy.

Key words: Vaccination hesitancy, decision-making, uncertainty, risk-taking, somatic marker hypothesis, vaccinators, non-vaccinators

INTRODUCTION

On the last day of 2019 a novel severe acute respiratory syndrome associated with the coronavirus 2 (SARS-CoV-2), causing a highly transmissible and sometimes lethal pneumonia (COVID-19), was first reported in Wuhan, Hubei Province, in Central China (Sadeghi et al 2020; Gorbalenya et al. 2020; Aknin et al. 2021). Global statistics show that, as of 31 May of 2023, there have been 767,364,883 confirmed cases of COVID-19, including 6,938,353 deaths, reported to WHO (Morga et al 2023); and a total of 13,355,264 024 vaccine doses have been administered[1].

Despite substantial evidence that COVID-19 vaccines reduce infection and death from COVID-19 (Baden et al., 2021; Liang et al., 2021), vaccination persists in being debated. Besides the diversity of vaccines and vaccine combinations, widespread and rapid global communication complicates vaccination controversies (Larson et al., 2014). One of the unremitting debate dimensions is the resistance to vaccination by weighing the benefits against the potential harms. Anti-vaccination is considered a context-specific, complicated phenomenon that varies according to time, location, social circumstances, personal backgrounds, and type of vaccine (Dubé et al., 2013; MacDonald et al., 2015). Although the variables detailed above impact the decision-making process regarding vaccination, prevalent features can also be found in individual determinants of vaccine acceptance or refusal (Dubé et al., 2013). Psychological factors can emerge as a characteristic feature of these individual determinants (Larson et al., 2014; Schmid et al., 2017).

Thus far, a wide variety of psychological processes have been explored concerning vaccine hesitancy. Individuals with low levels of openness to experience, agreeableness, and conscientiousness but high levels of altruism and neuroticism keep negative attitudes toward COVID-19 vaccines (Murphy et al., 2021; Roshchina et al., 2022; Salerno et al. al., 2021). Besides, the psychological factor of one's attitude toward risk significantly impacts their decision to accept vaccination (Roshchina et al., 2022). Factors such as the risk associated with the disease, the perceived severity of the disease, the risk of getting sick, and the risk-favoring affect the probability of being vaccinated (Betsch et al., 2018; Karlsson et al., 2021; Roshchina et al., 2022). Investigations have revealed that the decision-making process about vaccination is an attitude that can be influeced by various factors (MacDonald et al., 2015).

In neuropsychological research, decision-making behavior is examined in terms of two different paradigms as decisions under risk and decisions under uncertainty (Brand et al., 2006). These two paradigms have been the interdisciplinary research subjects in judgment and decision-making inspections (Loewenstein et al., 2001b). In decision-making under risk, knowledge about consequences and probabilities of reward and punishment is primarily available (Bechara, 2004; Brand et al., 2006). In this sort of decision-making, judgments are constructed based on information about the situation and potential outcomes, and the reward and punishment of preferences can be considered systematically (Brand et al., 2006). In decision-making under uncertainty, the probability of reward-punishment is un-

[1] https://covid19.who.int/ (access: 2023.05.31).

certain, and the prior information about the results is implicit (Brand et al., 2006). Per the somatic marker hypothesis, in situations of uncertainty where the details about the results are implicit, people should follow their intuitions and emotions (Damasio, 1996; Damasio R. Antonio, 1994). According to the somatic marker hypothesis, emotions guide decision-making when the outcome of one's choices regarding reward and punishment is uncertain (Naqvi et al., 2006). Emotions consist of somatic changes. These somatic states emerge in the decision-making process and work as an automatic alarm, marking specific options as advantageous and the other options as disadvantageous (Dunn et al., 2006; Naqvi et al., 2006). An automatic alarm reduces the problem area to a traceable size, making it more likely to produce an accurate decision among fewer options (Damasio R. Antonio, 1994).

It is assumed that individuals determine to get vaccinated through risk comparison (Hobson-West, 2003). Risk comparisons, such as the cost-benefit analysis, are intended to demonstrate the fallacy of choosing not to accept vaccination (Hobson-West, 2003). However, risk perception generally includes an emotional dimension of fear and anxiety (Loewenstein et al., 2001a; Slovic et al., 2004). Therefore, the decision to be vaccinated can be affected not only by cost-benefit analysis, but also by emotional processes. Making health-related decisions, such as getting vaccinated, can be tough because the information available may be uncertain or disputed. In particular, the long-term consequences of a new treatment, such as the Covid-19 vaccine, are unknown, and statistically cost-benefit calculations can be challenging. In this regard, individuals may have to decide in uncertain circumstances. Based on the hypothesis that emotions can also guide the decision to vaccinate or not, in this study, we aimed to investigate the decision-making processes of vaccination under uncertainty. The secondary aim of the study is to evaluate the relationships between the participants' decision-making and depression, anxiety, impulsivity, and vaccine hesitancy levels.

METHOD

Participants

The study data were collected face-to-face between January and April 2021. The study included 70 participantsvaccinated against Covid-19 and 70 not-vaccinated against Covid-19, matched for age, sex, and education level. Ten participants with missing scale scores were not included in the analyses. The total sample of 140 participantsconsisted of 74 women (%52.9) and 66 men (%47.1); it was determined that their ages varied between 18 to 56(Average = 29.12, S = 9.73). Inclusion criteria for the study were: being between 18-65, being able to read and write, and agreeing to participate. Illiteracy and being diagnosed with Covid-19 in the last three months were determined as the study's exclusion criteria.

Procedure

The study was approved by the University of Health Sciences, Hamidiye Scientific Research Ethics Committee (615/2021). After clarifying the purpose and method

of the study to the participants, their written informed consent was received. It took approximately 35-40 minutes to complete the scales and administer the test. Sociodemographic Data Form, Beck Depression Inventory (BDI), Beck Anxiety Inventory (BAI), Barratt Impulsivity Scale Short Form (BIS-11-SF), The Scale of Vaccine Hesitancy (SVH), and IOWA Gambling Test (IGT) were administered to the participants.

Assessments

Sociodemographic Data Form: A data form prepared by researchers to obtain information such as gender, age, education status, marital status, occupation, being vaccinated against Covid, and being diagnosed with Covid in the past, created for the study.

Beck Depression Inventory (BDI): It was developed to determine the presence and severity of depressive symptoms (A. T. Beck et al., 1961). It consists of 21 items, and each item is scored between 0 and 3. The scale is scored between 0-63; a high score indicates the severity of depression. A validity and reliability study was conducted for the Turkish population (Hisli, 1989).

Beck Anxiety Inventory (BAI): It was developed to determine the frequency of anxiety symptoms (A. Beck et al., 1988). It consists of 21 items, each scored between 0-3; the scale is scored between 0-63. A high total score indicates a high level of anxiety severity. A validity and reliability study was conducted for the Turkish population (Ulusoy et al., 1998).

Barratt Impulsivity Scale-Short Form (BIS-11-SF): It is a 15-item self-report scale that evaluates the impulsivity structure. It consists of 3 sub-dimensions: not planning, motor impulsivity, and attention impulsivity. Items are scored between 1-4; high-scale scores indicate high impulsivity. A validity and reliability study was conducted for the Turkish population (Tamam et al., 2013).

The Scale of Vaccine Hesitancy (SVH): It was developed to determine individuals' anti-vaccination levels (Kılınçaslan et al., 2020). The scale consists of 21 items and four sub-dimensions (benefit and protective value of vaccine, vaccine hesitancy, solutions for non-vaccination, legitimization of vaccine hesitancy). Since the first five items of the scale consist of statements in favor of vaccines, they are reverse-coded. The scale is between 21 and 105; high scores indicate that the individual's opposition to vaccination is high.

Iowa Gambling Task (IGT): IGT is an experimental test that simulates real-life decision-making, including components such as uncertainty, reward, and punishment (Bechara et al., 1994). In this task, the participants are given an advance of 2000 Turkish Liras (TL) as computer money at the beginning. Participants are asked to make as vast money as possible during the test by making choices from four decks of cards (A, B, C, D) displayed on the computer screen. The participant chooses a total of 100 cards, whereas this information is not given to the participant. The decision-making behavior among the decks varies according to the reward and punishment obtained due to the card selected from each deck. These rewards and punishments are pre-programmed and are not known by the participant. A and B decks are risky decks that make much money but also lose much in the long run. C

and D decks, on the other hand, are advantageous and risk-free in the long run, with little gain and little loss. Participants are expected to learn this rule as the test progresses. In a selection of 100 cards, choosing more from decks A and B results in a net loss, while choosing more from decks C and D results in a net win. A high score on the task indicates satisfactory decision-making performance. A validity and reliability study was conducted for the Turkish population (Içellioğlu, 2015).

Statistical analysis

SPSS program with version 20.0 for Windows was used for statistical analysis. The demographic characteristics of the groups and test findings were analyzed as follows: Comparisons of numerical variables in two independent groups were made with Student's t-test under normal distribution conditions and Mann Whitney-U test when normal distribution condition was not met. Chi-Square Analysis was used to make a comparison of rates in independent groups. Pearson correlation analysis was operated when the correlations between variables were provided with normal distribution conditions; when normal distribution was not achieved, Spearman correlation analysis was employed. The relationship between decision-making and other variables was analyzed using linear regression analysis. The statistical significance level was accepted as $p<0.05$.

RESULTS

The research sample comprises 140 participants, 70 vaccinated and 70 not vaccinated. The study subject demographics are presented in Table 1. There was no statistically significant difference between the groups in terms of age ($p=0.072$), gender ($p=0.090$), years of education ($p=0.107$), depression score ($p=0.420$), and anxiety score ($p=0.135$) (Table 1).

The vaccine hesitancy scores of the participants were analyzed; levels of the SVH-benefit and protective value of vaccine, SHV-vaccine hesitancy, SVH-solutions for non-vaccination, SVH-legitimization of vaccine hesitancy subscales, and SVH-total scores of the non-vaccinated participants were statistically higher than the vaccinated group ($p < 0.001$ and Cohen's $d = 1.11$; $p <0.001$ and Cohen's $d = 1.25$; $p <0.001$ and Cohen's $d =1.51$; $p <0.001$ and Cohen's $d = 0.90$; $p <0.001$ and Cohen's $d = 1.51$, respectively) (Table 2).

No statistically significant difference was encountered between the vaccinated and non-vaccinated groups regarding BDI-total scores and subscales. A statis-

Table 1. Differentiation of groups according to sociodemographic data and Beck scores

Variables	Vaccinated (n=70)	Non-Vaccinated (n=70)	F	P
Age (yr)	28.99 ± 9.25	31.94 ± 10.05	2.26	.072
Sex (Female), n (%)	42 (%60)	32 (%53.3)	2.86	.090
Education (yr)	14.46 ± 3.18	13.51 ± 3.68	1.96	.107
BDI scale scores	9.60 ± 5.95	8.74 ± 6.64	.494	.42
BAI scale scores	10.51 ± 7.23	8.76 ± 6.60	.388	.135

Abbreviations: BAI: Beck Anxiety Inventory scale, **BDI:** Beck Depression Inventory Scale

tically significant difference was found between the groups regarding the IGT-5 sub-block. The IGT-5 score of the non-vaccinated group was statistically significantly lower than the vaccinated group ($p<0.05$ and Cohen's $d=0.35$). There was no statistically significant difference between the groups regarding IGT-total score and other sub-blocks (Table 3, Figure 1).

Table 2. The differentiation of the groups according to the vaccine hesitancy subscales

Variables	Vaccinated (n=70)	Non-Vaccinated (n=70)	F	P
Benefit and protective value of vaccine	12.06 ± 4.96	17.23 ± 4.35	1.32	**.000**
Vaccine hesitancy	15.74 ± 5.16	22.21 ± 5.18	.47	**.000**
Solutions for non-vaccination	11.21 ± 3.80	17.39 ± 4.35	1.45	**.000**
Legitimization of vaccine hesitancy	7.73 ± 3.42	10.81± 3.39	.09	**.000**
Vaccine hesitancy-total score	46.76 ± 13.70	67.80 ± 14.12	.11	**.000**

Table 3. Impulsivity and decision-making scores of the participants

Variables	Vaccinated (n=70)	Non-Vaccinated (n=70)	F	P
BIS-15np	9.47 ± 3.00	9.07 ± 2.33	2.59	.38
BIS-15m	8.63 ± 2.46	8.41 ± 2.64	.09	.62
BIS-15a	8.53 ± 2.39	8.49 ± 2.22	.106	.91
BIS-15total score	26.61 ± 6.76	26.24 ± 5.76	.95	.73
IGT-1 (1-20)	-1.46 ± 4.51	-.94 ± 5.00	1.06	.52
IGT-2 (21-40)	-.74 ± 3.84	.14 ± 4.10	.02	.19
IGT-3 (41-60)	-.31 ± 5.06	-.43 ± 5.44	.15	.90
IGT-4 (61-80)	1.49 ± 6.36	-.34 ± 6.24	.98	.09
IGT-5 (81-100)	2.14 ± 6.91	-.49 ± 8.17	.34	**.04**
IGT-total score (1-100)	.89 ± 17.67	-2.57 ± 16.87	..67	.24

Abbreviations: BSIa: Barratt **I**mpulsiveness Scale-Short Form- attentional impulsivity, **BIS-15m:** motor impulsivity, **BIS-15np**: non-planning, **IGT: I**owa Gambling Test

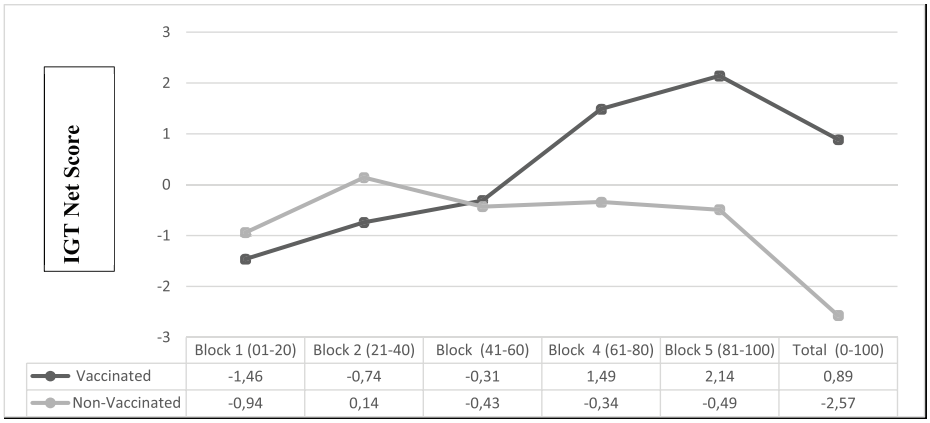

Fig.1. Decision making performance among groups. The mean net number of chosen cards (C+D) – (A+B) by the vaccinated and non-vaccinated group across five blocks each consisting of 20 trials. Positive net scores indicate advantageous decision-making performance, while negative net scores indicate disadvantageous decision-making performance.

Table 4. Examining the existence of a relationship between the variables

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
BDI (1)	1	**.60****	.08	.10	.16	.08	.11	**.36****	**.27****	**.38****	**.40****	-.04	-.09	-.15	-.12	-.08	**-.18***
BAI (2)		1	.10	.11	.14	.09	.11	**.27****	**.22***	**.32****	**.32****	.05	-.12	-.09	-.09	-.15	-.16
Benefit and protective value of vaccine (3)			1	**.66****	**.70****	**.63****	**.87****	.01	-.02	.03	.03	-.06	.00	.09	-.15	**-.21***	-.15
Vaccine hesitancy (4)				1	**.77****	**.62****	**.89****	-.10	-.03	-.02	-.06	.04	.13	.03	-.04	-.08	-.02
Solutions for non-vaccination (5)					1	**.64****	**.90****	.01	-.01	.01	.02	.01	.02	-.05	-.14	**-.23****	**-.17***
Legitimization of vaccine hesitancy (6)						1	**.80****	.14	.05	.15	.15	.03	.03	.03	-.07	-.11	-.05
Vaccine hesitancy-total score (7)							1	-.01	-.02	.03	.02	.01	.05	.02	-.13	**-.19***	-.13
BIS-15np (8)								1	**.41****	**.54****	**.81****	-.03	**-.23****	-.16	**-.19***	-.10	**-.23****
BIS-15m (9)									1	**.48****	**.76****	.02	-.10	-.16	.06	-.05	-.06
BIS-15a (10)										1	**.81****	.13	-.09	**-.19***	-.04	-.07	-.09
BIS-15total score (11)											1	.03	**-.18***	**-.22****	-.11	-.13	**-.20***
IGT-1 (12)												1	**.20***	-.01	.15	.03	**.41****
IGT-2 (13)													1	**.35****	.15	.10	**.48****
IGT-3 (14)														1	**.30****	.16	**.54****
IGT-4 (15)															1	**.50****	**.76****
IGT-5 (16)																1	**.70****
IGT – Total score (17)																	1

Abbreviations: BAI: Beck Anxiety **I**nventory scale, **BDI:** Beck Depression **I**nventory Scale, **BSIa:** Barratt **I**mpulsiveness Scale-Short Form- attentional impulsivity, **BIS-15m:** motor impulsivity, **BIS-15np**: non-planning, **IGT: I**owa Gambling Test

Correlation analysis was performed to evaluate whether there was a statistically significant relationship between the participants' decision-making scores, impulsivity, and other clinical variables. A statistically significant positive correlation was found between participants' depression scores with BAI (r = .60, p <.01), Barratt-non-planning subscale (r=.36, p<.01), Barratt-motor impulsivity subscale (r=.27, p<.01), Barratt-attention impulsivity subscale (r=.38, p<.01) and Barratt total scores (r=.40, p<.01).

Besides, a statistically significant positive correlation was found between participants' anxiety scores with the Barratt-non-planning subscale (r=.27, p<.01), Barratt-motor impulsivity subscale (r=.22, p<01), Barratt-attention impulsivity subscale (r=.01). 32, p<.01) and Barratt-total scores (r=.32, p<.01). A statistically significant negative correlation was found between the participants' IGT-2 scores and Barratt-total scores (r=-.18, p<.05). In addition, a statistically significant negative correlation was found between IGT-3 scores and Barratt-attention impulsivity subscale (r=-.19, p<.05) and Barratt-total scores (r=-.22, p<.01). Similarly, a statistically significant negative correlation was found between IGT-4 scores and Barratt-not planning subscale (r=-.19, p<.05).

On the other hand, IKT-5 scores and SVH-benefit and protective value of vaccine subscale (r=-.21, p<.05), SVH-solutions for non-vaccination subscale (r=-.23, p<.01), and SVH- vaccine hesitancy subscale (r=-.19, p<.05) scores was found to be statistically significantly correlated in the negative direction. Finally, participants' IGT-Total Scores and BDI (r=-.18, p<.05), Barratt-not planning subscale (r=-.23, p<.01), Barratt-total score (r=-.23), p<.01) and SVH-solutions for non-vaccination subscale (r=-.20, p<.05) were found to have a statistically significant negative correlation (Table 4).

DISCUSSION

In the present study, vaccinated and non-vaccinated individuals' risk-taking and decision-making processes were compared under uncertain conditions. To our knowledge of the literature, the present study is the first to examine decision-making behavior under uncertainty in vaccine hesitancy with IGT. The primary conclusion of this study is that the non-vaccinated group's decision-making performance under uncertainty was worse than the vaccinated group. A recent study by Roshchina et al. (2022) found that individuals' risk attitudes predicted their intention to be vaccinated, and risk-favoring was positively associated with anti-COVID-19 (Roshchina et al., 2022). In addition, the same study specified that people who are hesitant to the vaccine have high risk-favoring scores; in contrast, people who agree to be vaccinated show risk-aversive attitudes. If the risks of vaccine-preventable diseases are perceived to be low, vaccination may not be considered necessary (MacDonald et al., 2015). A meta-analysis indicated that, adults' perception of risk strongly predicts their vaccination behavior (Brewer et al., 2007). The present study's findings are in parallel with earlier investigations. The non-vaccinated group included in the study made more choices

from disadvantaged and risky decks. This non-vaccinated group was more sensitive to immediate reward rather than long-term gains, and their choice resulted in a net loss. The vaccinated group, on the other hand, made more selections from low-risk, low-loss, long-term advantageous decks, and their selections resulted in net gains.

In the current study, the net scores of each block were examined separately to evaluate the increasing learning effect of the gambling task. It was detected that the scores of the vaccinated group (including the total score) increased above 0 at block 4. The vaccinated group increased their performance by choosing more advantageous decks after the first 60 card selection and succeeded in showing a learning effect. The non-vaccinated group showed a learning effect only in block 2 and continued to choose from disadvantageous cards in the following blocks. In this task, profitable decision-making; has been determined that it is associated with different cognitive functions such as making cost-benefit analysis, evaluating the loss-gain possibilities, keeping the previous card selection in working memory, and benefiting from the feedback obtained after the choices (van Duijvenvoorde et al., 2012). From this point of view, the non-vaccinated group could not benefit from feedback sufficiently in this task (See Fig. 1). Besides, decision-making in this task has also been associated with reverse learning (Brand et al., 2006; Dunn et al., 2006). It is also associated with backward learning because the disadvantageous A and B decks give high wins at the beginning of the test, and after a few tries, choosing these decks results in increased losses. Participants are expected to learn that these decks are disadvantageous and will result in long-term losses (Brand et al., 2006). An advantageous decision requires switching from decks with high rewards but also high penalties in the long run to decks that are less risky and disadvantageous (Bull et al., 2015; Clark et al., 2004). Based on the test performance of the unvaccinated group, their backward learning skills are vulnerable in uncertain situations with reward and punishment stimuli.

The non-vaccinated participants in the study performed better in IGT-2 than the vaccinated participants, and they finished this section with advantageous decisions. It may be possible to interpret this finding in terms of the pre-hunch period (Bechara et al., 1997). In the pre-hunch period, healthy participants chose from A or B decks and could not comprehend the content of the task even though they were punished. They initiated to choose advantageously before discovering which strategy worked best; implicit processes guided the participants' choices. From this point forth, the fact that the non-vaccinated group makes advantageous choices in the pre-hunch period may be related to unconscious processes directing them. However, the participants showed an increasingly inadequate performance despite this stage. In other words, with the progress of the test, their choices started to become disadvantageous as they reached conscious information. Another remarkable finding of the current study is that the IGT-5 score of the non-vaccinated group was statistically significantly lower than the vaccinated group. Bechara et al. (1997) defined this part as the conceptual phase in

the study mentioned above.The participants have grasped the differences in rewards and punishments between the IGT decks and reached a piece of fully conscious information about the content of the task in this deck. The present study determined that the vaccinated participants understood the task's content towards the end of the test and turned to advantageous decks. However, an equivalent finding was not encountered in the non-vaccinated group. It may be perceived as a speculative comment at this stage; however, giving more information about the vaccine to anti-vaccine individuals may not change their decision.

Health-related decisions are critical situations in which decision-making at risk is critical in the circumstances with certain or uncertain outcomes. For example, in a medical treatment where the risk is certain, a statistical decision can be made based on certain benefits or side effects. In such situations, decisions can be made based on some information about the situation and related outcomes, and different options can be systematically evaluated in terms of long-term benefits and harms (Brand et al., 2006). However, from a different view, it is argued that health-related decisions often involve a high level of uncertainty and varying degrees of potential risk (Damnjanović et al., 2018). Risk is thought to be related to uncertainty at a fundamental level (Hobson-West, 2003). It is stated that the decision to be vaccinated is also influenced by factors other than a rigid risk comparison, such as benefit-harm (Dubé et al., 2013). Making a decision regarding a recently released vaccine can be burdensome, particularly since it is challenging to estimate the cost and benefit statistically, and the long-term results are still obscure. Individuals need to construct decisions under uncertainty in situations involving such diverse factors. The decision to get vaccinated also appears to be influenced by implicit processes; it may not be a well-thought-out decision in which the risks are calculated. So how do individuals make this decision? According to the current research results, the SMH may provide an additional explanation for the decision to be vaccinated. According to the somatic marker hypothesis, emotions guide decision-making when the outcome of one's alternatives regarding reward and punishment is uncertain (Naqvi et al., 2006). According to this hypothesis, people should follow their feelings and intuitions in uncertain situations where the information about the results is vague (Damasio, 1996; Damasio R. Antonio, 1994). Emotions play a critical role in risk aversion and long-term advantageous decision making in uncertain situations. In a study of healthy populations, some groups that do not see or fear the possible future outcomes as others make decisions indifferently towards future outcomes (Loewenstein et al., 2001b). In ambiguous situations, somatic markers work as an automatic alarm, marking available response options with an emotional signal (Dunn et al., 2006). The automatic alarm protects the person against future harm without going any further and makes it possible to make an accurate decision from fewer options (Damasio R. Antonio, 1994). Somatic signs of right or wrong choices enable the person to make and maintain beneficial decisions (Bechara et al., 2000). Emotions increase the accuracy and efficiency of the decision-making process; the absence of emotions reduces decision-making performance (Damasio R.

Antonio, 1994). The decision-making of vaccination is an intricate process influenced by cultural, religious, political, cognitive, and emotional factors (Dubé et al., 2013). In decision-making under uncertainty, emotions may mediate the link between cognitive assessments of risk and risk-related behavior (Loewenstein et al., 2001b). It was found that those who reacted more highly to adverse events made more choices from low-risk, less-losing, long-term advantageous decks. More negative affect represented more avoidance of high-loss options; more positive affect was associated with higher-paying options (Peters Paul Slovic, 2000).

Limitations

The findings of our study should be interpreted considering various limitations. One of the main limitations is the small number of participants, which is also the most crucial. In addition, despite the assurance of anonymity in the answers during the data collection process, the participants may have answered the questions far from reality with the concern of desirability. On the other hand, individuals' attitudes towards COVID-19 vaccines may change with different pandemic phases. Despite all these limitations, the findings presented cover a late period when vaccines are easy to access; there are some limitations for non-vaccinated people and detailed information about the vaccine. In this respect, the present study gives information about the decision-making process under uncertainty in vaccination hesitancy.

CONCLUSION

As a result, unvaccinated individuals made more choices from disadvantageous/risky decks in the long run during the decision-making task and were prone to take risks under uncertainty. In addition to the reasons existing in the vaccine hesitancy literature, the impact of implicit processes and emotions should be considered. One of the best ways to manage an uncertain and implicit process is to inform vaccine-hesitant individuals about uncertainty. Acknowledging that there is uncertainty about the consequences of whether or not to vaccinate, it is crucial to understand why people are reluctant to vaccinate. Considering that emotional and implicit processes can be effective in vaccine acceptance, approaches that eliminate vaccine hesitations, such as establishing better communication approaches and addressing their dilemmas and fears with respect, may be achievable.

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