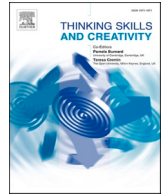




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Does thinking about coronavirus impact insight and analytical reasoning?

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ABSTRACT

Stress and threats have been shown to influence our cognition and performance. In a preregistered online experiment ($N = 446$), we examined whether thinking about the ongoing covid-19 pandemic influences creative (insight problem solving) and analytic thinking. We found no support for our a-priori hypothesized effect (decrease in insight problem solving and no change in analytical thinking), however, several unpredicted results emerged. Exploratory analyses revealed that both types of thinking were harmed, yet only in men. Interestingly, the effect of exposure on thinking about covid-19 was indirect and led to careless task completion – again, only in men. We discuss these intriguing results and propose potential explanations along with future studies directions.

1. Introduction

Although very recent, the deadly pandemic the world happens to be experiencing currently (April 2020) has already shown to influence various domains of human functioning, ranging from affective states, political and ideological views, to attitudes toward outgroup (Karwowski et al., 2020; Sorokowski et al., 2020). Yet, to the best of our knowledge, its effect on cognitive functioning remains unknown. The way we feel impacts the way we think, and motivations pilot our conducts. Moreover, our actual performance in tasks involving creative or analytical thinking is largely influenced by situational factors (Davis, 2009). Here, we test whether the stressful and threat-inducing circumstances, namely the coronavirus outbreak, affect our performance in solving tasks that require insight and analytical thinking. We experimentally tested the idea that thinking about coronavirus can stifle schema-breaking thinking while leaving analytical performance unchanged.

The prediction that coronavirus-related tension will hamper insight, conceptually close to creativity (Beisemann, Forthmann, Bürkner, & Holling, 2018; Danek & Salvi, 2020; Kounios & Beeman, 2009) stems from the motivational framework, which indicates that cognitive processes correspond with inclination to avoidance vs. approach – a discrepancy in goal setting (De Dreu, Baas, & Nijstad, 2012). Approach motivation implies a desire to reach positive outcomes, entails moving towards, and corresponds with promotion regulatory focus, while avoidance motivation corresponds with a prevention focus and entails moving away from negative outcomes (Higgins, 2000). Therefore, approach is motivated by pleasurable goals and avoidance by aversive ones. In these terms, anxiety and threat can be seen as avoidance-related states (but note that certain personal threats can increase avoidance in people with high self-esteem, see Cavallo, Fitzsimons, & Holmes, 2009; Park, 2010). These motivational tendencies (or regulatory foci) are tightly

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related to moods in a way that avoidance is related to negative, agitation-related moods (like being fearful, tense or worried), while approach resonates with positive activating ones (e.g., happiness) (Baas, De Dreu, & Nijstad, 2008). Activating moods that are negative in tone, likely triggered by thinking about the coronavirus pandemic, favors in-depth exploration of a number of cognitive categories and persistent, analytical, bottom-up processing of information (De Dreu, Baas, & Nijstad, 2008; Derryberry & Reed, 1998). They are, therefore, detrimental for a flexible way of thinking; they can, however, lead to creative outcomes through persistent deliberation (Nijstad, De Dreu, Rietzschel, & Baas, 2010).

On the other hand, while feeling positively aroused, people tend to explore the environment safely, use broad and inclusive cognitive categories, find remote associations between them, and switch perspectives with ease (De Dreu et al., 2008, 2012; Dreisbach & Goschke, 2004). Accordingly, approach orientation goes together with flexible thinking (De Dreu, Nijstad, & Baas, 2011; Gong, Kim, Lee, & Zhu, 2013) and insight problem solving (De Dreu et al., 2014). More importantly to our reasoning, avoidance does not, and it even impedes it (Mehta & Zhu, 2009; Roskes, De Dreu, & Nijstad, 2012), although not all studies have been consistent in reporting this pattern (e.g., De Dreu et al., 2008). One aspect that regulates the influence of motivational orientation on creativity is the regulatory success—when the desired end state is achieved, avoidance-oriented individuals are specifically prone to diminished creativity, but this tendency was not observed in the case of regulatory failure (Baas, De Dreu, & Nijstad, 2011). Compelling evidence suggests that while aiming to avoid failure or adverse outcomes, people become more alerted and focused on details. Moreover, they start to think in a more systematic and analytical manner, as an orientation toward avoidance narrows the attention scope leading to more local (rather than global) perception (Derryberry & Reed, 1998; Förster, Friedman, Özelsel, & Denzler, 2006; Roskes, Elliot, & de Dreu, 2014). Combining this evidence, we can expect that various threats can elicit creativity in certain conditions through systematic and analytical processing rather than through remote associations and schema-breaking.

Interestingly, the link between motivational tendencies and creativity has also been considered from the perspective of human biology. De Dreu et al. (2014) found that oxytocin (a hypothalamic neuropeptide crucial for bonding, trust, and prosocial behaviors, also responsible for upregulating the approach orientation; see Kosfeld, Heinrichs, Zak, Fischbacher, & Fehr, 2005) is related to creative performance. In a series of studies, the authors showed that endogenous oxytocin levels predict novelty seeking and creative ideation. They also confirmed the causality of this relationship—experimentally elevated oxytocin improved holistic (rather than detailed) processing, divergent (but not convergent) thinking, and resulted in higher scores on creative insights tasks (De Dreu et al., 2014). Importantly, elevated oxytocin levels impaired performance on tasks requiring analytical thinking assessed by Syllogistic Reasoning Task (see e.g., Khemlani & Johnson-Laird, 2012). This shows that the approach orientation does not equally impact both ways of thinking (analytical or holistic) and suggests that the avoidance orientation is also likely to affect cognitive processes differentially.

Threat avoidance can be chronic and treated as an individual difference (Roskes et al., 2014), but it can also be induced by external circumstances, such as punishment or potential failure (see, e.g., Roskes et al., 2012). Thinking about viral infection can presumably situationally boost aspiration to prevent oneself from negative outcomes. Thus, we see perceiving information about the coronavirus outbreak as potentially inducing avoidance motivation.

Finally, another framework aiming to explain the variation in creativity—the Diversifying Experience Model (Gołowska, Damian, & Mor, 2018)—provides further premises to anticipate that worrisome information about coronavirus may hinder creative thinking. According to this model, surprising and adverse events can differently impact creativity, depending on whether they are qualified as a threat or challenge. Individuals who possess sufficient resources may interpret the schema-breaking situation as a challenge and are likely to have their creative potential increased rather than hampered because the set-breaking events allow for adopting new habits, taking a different perspective, and thinking more flexibly (Crisp & Turner, 2011). However, once qualified as a threat, a diversifying experience is harder to cope with and leads, in turn, to more rigid thinking. Diversifying experience that hampers creativity when transgressing the threshold of being stimulating and beneficial has been reported across various domains, including immigration, abusive leadership or even psychopathology (Godart, Maddux, Shipilov, & Galinsky, 2015; Lee, Yun, & Srivastava, 2013; for a review see Gołowska et al., 2018). Likely, the diversifying experience of a pandemic, expanding in an exponential manner (Zhao et al., 2020), and affecting people of all ages and professions throughout the world, ranks above this threshold, as its negative consequences preoccupy attention and narrow the attention focus (Staw, Sandelands, & Dutton, 1981). We expect that activation of thinking about coronavirus will be appraised more as a threat than a challenge and will activate threat avoidance.

The pandemic is expected to have a multitude of adverse outcomes (Pew Research Center, 2020). The anticipation of not only health-related but also combined social and economic consequences should regulate avoidance strategies. In this fight, there is little to gain, but a lot to lose. Therefore, building on the literature on antecedents and consequences of avoidance motivation (Roskes et al., 2014), on threatening diversifying experiences (Gołowska et al., 2018), and, relatedly, on emotive roots of creative thinking (De Dreu et al., 2012), we hypothesize that experimentally primed saliency of coronavirus can hamper insight thinking. At the same time, it is not expected to influence analytical thinking.

2. The present study

In a preregistered online experiment, we examined whether making the recent threat associated with COVID-19 salient influences people's thinking and problem-solving. Drawing upon the previous study (Karwowski et al., 2020), which demonstrated that even brief information about coronavirus elevates people's anxiety, we predicted that making coronavirus salient will negatively influence the efficiency in solving tasks that require creative insight yet will not harm analytical thinking. In this study, we operationalized creativity as insight tasks: misleading problems that require restructuring of the problem representation and viewing it from a different angle in order to achieve the solution (Jason van Steenburgh, Fleck, Beeman, & Kounios, 2012). As such, they engage flexible and global

thinking mode (Baas et al., 2011). Creative insight tasks are accompanied by the “Aha” reaction – a surprising and emotional experience that differs from the end-state of analytical task not only perceptually, but also in neural activity in a way that insight solutions activate the right cerebral hemisphere (Bowden & Jung-Beeman, 2003; Chi & Snyder, 2011; Zhao, Zhou, Xu, Fan, & Han, 2014). Various tricky problems qualify as creative insight tasks, e.g. Remote Association Task (RAT) items (Mednick, 1968), short open-ended problems or visual tasks, and they are all frequently used as measures of creativity (Baas et al., 2011; De Dreu et al., 2008; Gocłowska, Baas, Crisp, & de Dreu, 2014). Moreover, insights, like other types of creativity, are influenced by mood (Jason van Steenburgh et al., 2012). We emphasize that equating insight thinking with creative thinking might prove controversial given relatively high correlation of insight tasks with intelligence (Lee, Huggins, & Therriault, 2014) and lack of relationships between insight problem solving and creative achievement (Beaty, Nusbaum, & Silvia, 2014; but see also Karwowski & Beghetto, 2019, Study 3). Here, we decided to rely on brief, open-ended insight problems, as previous study (Karwowski & Beghetto, 2019) demonstrated their predictiveness for observable creative behaviors in a way that was comparable with divergent thinking. However, as we highlight in our limitation section, adding divergent thinking tasks would enrich the potential generalizability of the findings presented below.

3. Method

The present study was preregistered, and the protocol is available at <https://aspredicted.org/pd57u.pdf>. The Ethics Committee at the Institute of Psychology, University of Wrocław has approved the procedure. We report how we determined our sample size, all preregistered data exclusions, all manipulations, and all measures used in the study. We organize our results section in a way that separates preregistered from exploratory analyses. The data that support the findings of this study are publicly available at <https://figshare.com/s/b4d09154364f453238d9>.

As mentioned in our pre-registration, we expected that activating thinking about COVID-19 will negatively influence people’s effectiveness in solving problems that are based on insights. Simultaneously, we did not predict such an effect in analytical thinking.

3.1. Participants

Based on power analysis (Gpower 3.11; Erdfelder, Faul, & Buchner, 1996), with $d = 0.30$ (the smallest effect size of interest), with α set to .05 and β to .90, the required sample size was estimated as 2×235 for a one-tailed test. As we expected that not all participants would pass our attention checks (see Procedure section), we aimed at having 500 participants. An independent research company collected data from a nationwide sample of $N = 500$ participants (250 women), aged 18–66 ($M = 36.74$, $SD = 11.40$). However, consistently with our expectations, 54 people (11 %) failed at least one of three attention checks (10 failed all three, 10 failed two of three, and 34 failed one of three).

Therefore, the final sample consisted of 446 participants (228 women, 51 %), aged 18–66 ($M = 37.21$, $SD = 11.48$), among whom 218 (109 women, 50 %) were randomly assigned to the control group and 228 (119 women, 52 %) to the experimental group, which is slightly below the required sample to find the $d = 0.30$. All participants provided informed consent to participate in the study and were compensated for participation.

3.2. Measures

Participants solved 23 tasks that measured their insight and analytical thinking. All tasks and their descriptive statistics are available in Table S1 in the online Supplementary material.

3.2.1. Insight

There were eight items adapted from Karwowski (2014). All items required insight thinking (e.g., “A woman has two sons who were born at the same hour of the same day of the same month of the same year. However, they are not twins – how is that possible?”), and were scored 0 if the answer was not correct and 1 if the answer was correct. Overall reliability was acceptable ($\omega = .67$).

3.2.2. Analytical thinking

Fifteen items were used to measure analytical thinking (12 tasks) and overall reasoning (3 tasks). Three tasks were adapted from International Cognitive Ability Resource (Condon & Revelle, 2014), and 12 analytical tasks (based on math material) were created for the current investigation. Overall reliability was estimated at $\omega = .89$, but one of the analytical tasks (the last one) was poorly correlated with the total score ($r = .20$), so we decided to rely on 14 tasks instead ($\omega = .90$).

3.3. Procedure

The procedure consisted of inviting respondents to participate in two, seemingly unrelated studies. At first, participants were randomly assigned to one of the two groups (i.e., coronavirus vs. control). Then, they were presented with three short press reports and asked to evaluate each of the press reports’ quality on three questions (i.e., whether the given press report is interesting and riveting; whether the vocabulary is understandable; and whether the given press report addresses socially relevant issues), using a seven-point Likert scale (ranging from 1 = *I completely agree*, to 7 = *I completely disagree*). In both experimental groups, the first two press reports were exactly the same (i.e., one was about a tree in the Amazon, and the other was about foldable laptops). The third press report was either about a coronavirus outbreak (coronavirus group) or about climate change (control group). All press reports were of similar

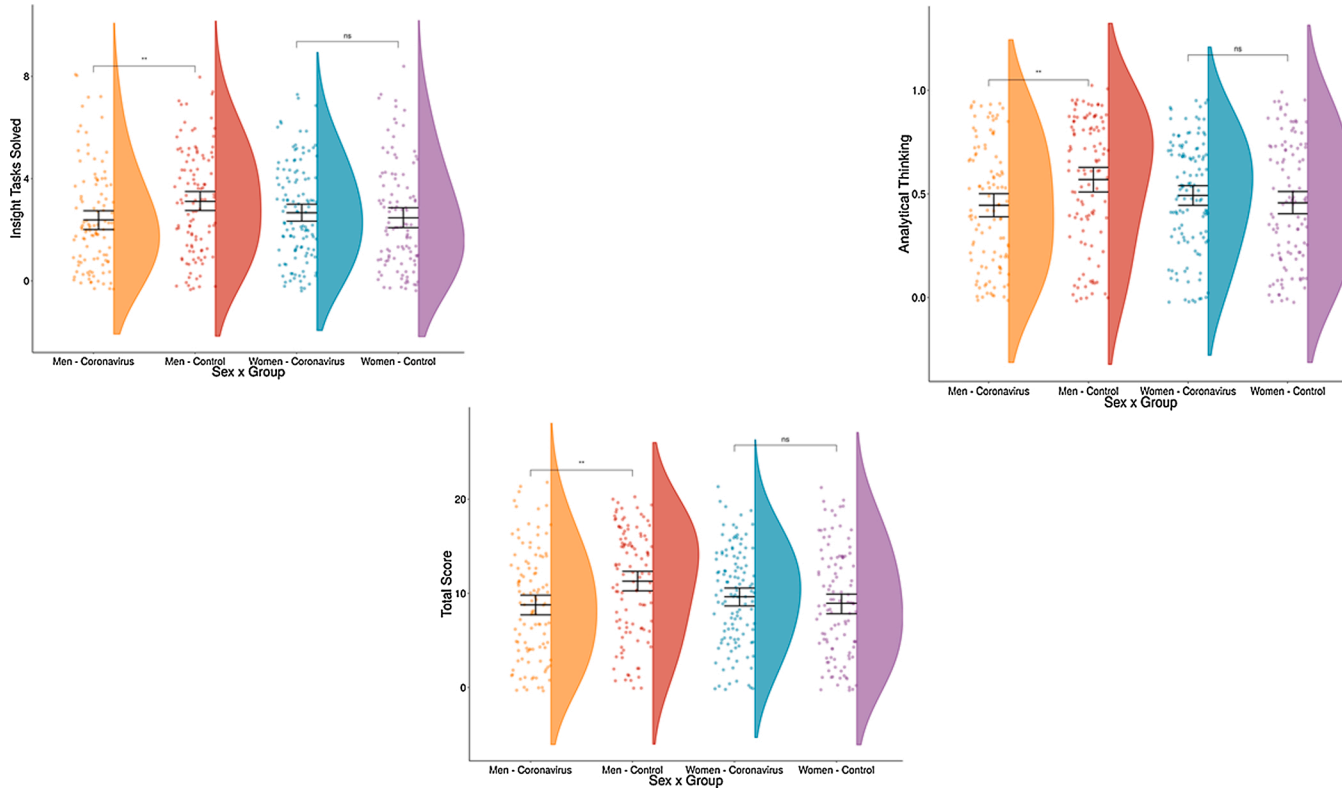


Fig. 1. Sex x Group interactions in relation to insight problem solving (upper left), analytical thinking (upper right), and the total score (bottom).

length (100–106 words). As the goal of the first part was to expose participants either to information about coronavirus threat or not, we did not analyze participants' ratings of the press reports. Following the evaluation of press reports' quality, the participants answered three single-choice questions regarding the content of each of the press reports (attention check). In all subsequent analyses, we used data only from participants who correctly answered all three questions. In the second part of the study, the participants solved the insight and analytical thinking problems. The data collection was conducted on March 10th and 11th 2020. The first case of a person infected with coronavirus in Poland was announced on March 4th, and the first death case was announced on March 12th.

4. Results

4.1. Preregistered confirmatory analyses

As preregistered, we started with Multivariate Analysis of Variance (MANOVA) with two variables of interests (insight and analytical thinking) as dependent variables and a group as a between-subject factor. The overall effect was not significant, $F(2, 443) = 1.38, p = .25$. We followed the analysis by two independent Analyses of Variance (ANOVAs), but they did not yield statistically significant effects either: insight, $F(1, 444) = 1.86, p = .17$, analytical thinking, $F(1, 444) = 2.36, p = .125$. Given our directional hypothesis in the case of insight, we also compared the groups with independent samples *t*-test and one-tail significance test. Still, the difference did not achieve the conventional threshold of significance: $t(444) = 1.36, p = .087$, Cohen's $d = 0.13$. The between-group differences were in the expected direction, meaning that the control group achieved higher scores ($M = 2.79, SD = 2.08$) than the experimental group ($M = 2.53, SD = 1.92$). The same pattern was observed in the case of analytical thinking: control group $M = .51, SD = .31$, experimental group $M = .47, SD = .28$, Cohen's $d = 0.15$.

4.2. Preregistered exploratory analysis

As exploratory analyses, we preregistered a Multivariate Analysis of Covariance (MANCOVA) with the same two dependent variables and with age and sex as covariates, followed by two subsequent Analyses of Covariance (ANCOVAs), but they did not change the overall pattern, so the details are described in supplementary online material.

4.3. Non-preregistered exploratory analyses

Our further exploratory analyses consisted of three steps. First, given that the results in insight and analytical thinking were robustly correlated ($r = .54, p < .001$), we also created a variable describing overall intellectual functioning in solving our tasks ($\omega = .89$). While the control group tended to solve more tasks ($M = 10.12, SD = 5.84$) than the experimental group ($M = 9.23, SD = 5.43$), this difference did not reach significance either: $t(444) = 1.67, p = .096, d = 0.16$.

Our second analysis used a 2×2 between group MANOVA with participants' sex and group as between-person factors and three variables (insight, analytical thinking, and overall score) as dependent variables. While the main effect of sex was not significant in any of the analyzed cases ($p = .36$ for insight, $p = .27$ for reasoning and $p = .18$ for the total score), there was an unpredicted, statistically significant effect of *Sex x Group* interaction in all three cases; for insight, $F(1, 442) = 5.97, p = .015, \omega^2 = .01$, for analytical thinking, $F(1, 442) = 8.37, p = .004, \omega^2 = .01$, and for the total score, $F(1, 442) = 9.20, p = .003, \omega^2 = .02$. Fig. 1 presents the interaction effects.

Post-hoc tests (with Tukey correction for multiple comparisons) showed that in the case of insight tasks, men from the control group obtained significantly higher scores ($M = 3.11, 95\% \text{ CI: } 2.74, 3.48$) than men from the experimental group ($M = 2.39, 95\% \text{ CI: } 2.01, 2.76$), $t(216) = 2.66, p = .037, d = 0.36$. The remaining differences were not significant.

In the case of analytical thinking, men from the control group obtained higher scores ($M = .57, 95\% \text{ CI: } 0.51, .62$) than men from the experimental group ($M = .46, 95\% \text{ CI: } .39, .50$), $t(216) = 3.04, p = .01, d = 0.41$. Additionally, the scores of men from the control group were higher than those achieved by women from this group ($M = .46, 95\% \text{ CI: } .40, .51$), $t(216) = 2.75, p = .024, d = 0.37$.

The same pattern was observed when the total score in both insight and analytical tasks was taken into consideration. Men from the control group performed better ($M = 11.29, 95\% \text{ CI: } 10.24, 12.34$) than men from the experimental group ($M = 8.78, 95\% \text{ CI: } 7.73, 9.83$), $t(216) = 3.24, p = .005, d = 0.44$. There was also a significant difference between men and women ($M = 8.94, 95\% \text{ CI: } 7.89, 10.00$) from the control group, $t(216) = 3.02, p = .01, d = 0.41$.

4.4. Did people care about the tasks they solved?

As solving insight tasks required that participants provided an answer to an open-ended question, in the process of scoring the tasks, we realized that while some participants tried to solve the tasks as asked, in some cases, there were clear signals showing that the participants did not take the tasks seriously. Instead of excluding such participants in a post-hoc manner, we decided to score each task not only for the correct (1) or incorrect (0) answer but also for potential carelessness. More specifically, two coders (first two authors of this article), scored eight insight tasks for potential carelessness of participants' answers. We classified as careless those responses where participants provided nonsensical answers, put random letters instead of answering, or when they did not answer three or more questions in a row. Theoretically, the range of this variable falls between 0 (if there were no symptoms of careless responding) and 8 (if participants answered all items carelessly) for each coder. The coders were consistent ($\omega = .78$), so their scores were averaged into the "careless" variable. As it was skew ($M = 0.29, SD = 0.81, \text{ range } 0\text{--}7.50, \text{ skewness} = 3.91$), we square root transformed it for parametric analysis ($M = 0.21, SD = 0.50, \text{ skewness} = 2.31$).

Were participants from experimental and control groups equally engaged in solving the tasks? They were not. Welch’s independent samples *t*-test has shown that carelessness in the experimental group ($M = 0.27, SD = 0.55$) was significantly higher than that in the control group ($M = 0.14, SD = 0.43$), $t(426) = 2.76, p = .006, d = 0.26$.

Then, we examined whether carelessness mediated the relationship between our manipulation, and the results achieved in insight and analytical tasks. We tested three mediation models with a group (manipulation or lack thereof) as an independent variable, carelessness as a mediator and insight, analytical, and total scores as dependent variables. As illustrated in Fig. 2, in all these cases, we did observe statistically significant, negative indirect effects. Making coronavirus salient resulted in more careless responding, which then resulted in a lower number of properly solved insight tasks, analytical tasks, and overall cognitive tasks.

4.5. Was carelessness after the manipulation sex-specific?

The last step of our analyses integrated the two intriguing, yet unexpected effects we obtained, namely (1) sex-specific effects of manipulation with Covid-19 saliency and (2) the indirect effect of manipulation through careless responding. To explore whether these two effects were related, we proceeded with a moderated mediation model. We were particularly interested in testing for moderated mediation, namely the possibility that participants’ sex moderates the indirect effects previously observed.

As illustrated in Table 1, in all three cases (insight, analytical thinking, total score), the previously reported indirect effect (manipulation – careless responding – weaker results in cognitive tasks) was found only among men, while it was not statistically significant among women. *Manipulation x Sex* interaction significantly predicted careless responding in such a way that making coronavirus salient resulted in more careless responding among men ($\beta = .23, p < .001$), but not among women ($\beta = .03, p = .60$). When we controlled for carelessness in regression models, the previously observed *Manipulation x Sex* interaction held in the case of all dependent variables (albeit in the case of insight tasks it *p*-value dropped to non-significant, $p = .06$), showing that only among men manipulation with coronavirus did influence the results obtained in cognitive tasks. Finally, in none of the cases was the *Carelessness x Sex* interaction significant; the negative effect of careless responding translated into lower scores equally among men and women.

5. Discussion

In the current study, we tested the idea that once exposed to information about coronavirus (which is likely to induce a threat), insight problem solving (but not analytical thinking) will be harmed. Contrary to our predictions, reading press reports about coronavirus did not harm insight thinking as such. In turn, rather than specifically affecting creative insight, it hampered both types of thinking indirectly: through increased carelessness in task completion. Interestingly, these effects (both direct and indirect one) were only present in the male sample, while our manipulation did not differentiate women from both conditions in any significant way.

The unpredicted role of sex is an interpretational challenge—not only was men’s analytical and general thinking performance affected by the information about coronavirus, but they were also more careless in responding after the manipulation. One, somehow speculative, explanation is that the effect occurred because women’s performance has been influenced by press reports in the control condition, too. Our control condition consisted of two press reports that were identical in both groups, and one report that concerned climate change issues. What cannot be ruled out is that women (but not men) from both groups could have experienced threat, and their performance was therefore diminished. Previous studies have shown that women, in general, are more concerned with climate change and other environmental issues (Davidson & Haan, 2012; Goldsmith, Feygina, & Jost, 2013; McCright, 2010). At the same time, there are studies reporting sex differences in attitudes, and probably also susceptibility to covid-19 related stress and these studies also view women as potentially more prone to it (De La Vega, Barquin, Boros, & Szabo, 2020; Gerhold, 2020; but see Mertens, Gerritsen, Salemink, & Engelhard, 2020). Still, however, this is just an example of possible explanations of some unexpected patterns in results,

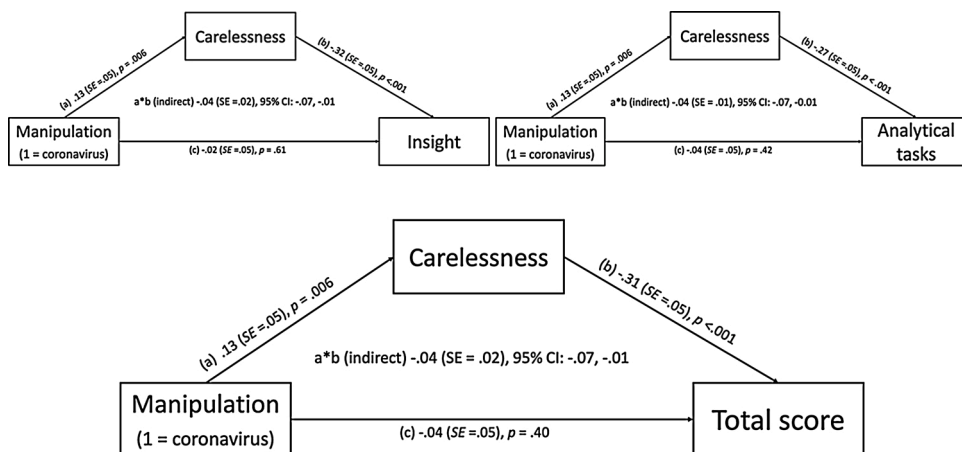


Fig. 2. Mediation models testing how the information about coronavirus influences careless responding and indirectly decreases the effectiveness in solving insight tasks (upper left), analytical thinking (upper right), and overall score (bottom). Coefficients are standardized.

Table 1
Summary of Moderated Mediation Models.

Predictor	Carelessness (Mediator)	Insight Thinking	Analytical Thinking	Total Score
Manipulation	.13** [.04, .22]	-.02 [-.11, .07]	-.03 [-.12, .06]	-.04 [-.12, .05]
Sex	-.18 [-.36, .01]	-.14 [-.32, .03]	-.15 [-.33, .03]	-.18* [-.36, -.01]
Manipulation x Sex	-.20* [-.38, -.01]	.17 ($p = .06$) [-.01, .35]	.21* [.03, .39]	.22* [.04, .40]
Carelessness	-	-.32*** [-.41, -.23]	-.27*** [-.36, -.18]	-.31*** [-.40, -.22]
Carelessness x Sex	-	-.02 [-.20, .16]	.06 [-.12, .24]	.04 [-.14, .22]
Conditional Indirect effects: Manipulation-Carelessness-DV				
Men	-.07* [-.13, -.03]		-.07* [-.12, -.03]	-.08* [-.13, -.03]
Women	-.01 [-.06, .03]		-.01 [-.04, .02]	-.01 [-.05, .03]
Moderated Mediation	.06 [-.001, .13]		.06* [.01, .12]	.07* [.01, .13]

Note. All continuous variables: dependent variables and carelessness (mediator) were z-transformed before analysis to facilitate interpretability, therefore they could be interpreted as standardized regression coefficients (β s), while the effects of dichotomous variables (manipulation and sex) could be interpreted as Cohen's d s. Manipulation coded $-1 =$ control, $1 =$ coronavirus, sex coded $0 =$ men, $1 =$ women (centered for analyses).

* $p < .05$.

** $p < .01$.

*** $p < .001$.

and it should not be taken uncritically. To unravel these speculations, future studies should involve a more neutral control condition, in which no threat of any kind is activated.

Further exploration of our data suggested that, when exposed to a report about coronavirus, men became less attentive to the task and did not put enough cognitive effort into completing the task. Instead of giving any reasonable answer (no matter whether right or wrong or even stating openly that they do not know) – they typed in random signs or random answers unrelated to the task, suggesting that they simply ignored it. The fact that processing information about coronavirus increased carelessness suggests that the lower scores in analytical and insightful thinking may result from lower motivation to engage in the thinking process and thus imply an attitudinal switch. This explanation is not mutually exclusive with the one suggesting that when exposed to coronavirus, people (only men in our case, though) are less capable of finding the right solution. Nevertheless, it seems plausible that processing information about this highly important, timely, and uncontrollable issue makes people more ignorant of the study task because they perceive it as less important or less worth undertaking. In other words, a threat could be interpreted as a distractor. What also remains unknown is why this mediation occurred only in men.

Our operationalizations of creative insight and analytical thinking turned out to be substantially correlated. Moreover, patterns of results where both of them were considered as dependent variables are highly consistent. This brings to mind the possibility that we might have not fairly differentiated these two types of cognition (i.e., creative and analytical thinking). Some arguments are supporting this surmise. Firstly, insight and analytical tasks are both highly related to intelligence (Lee et al., 2014), which suggests that once affecting cognitive abilities in general, our manipulation was likely to impact both types of thinking. Moreover, some studies suggest that processes by which insight vs. analytical problems are solved, do not differ much. These similarities are expressed in common heuristics used in both types of tasks and analogical transfers of information during both problem-solving settings (Chronicle, MacGregor, & Ormerod, 2004; Ormerod, MacGregor, & Chronicle, 2002). We suggest that future studies could direct their focus to a more pronounced distinction between creative and analytical cognition by using either divergent thinking tasks or product-based assessment of creativity.

One further aspect that limits findings of our study is that although we tested the hypothesis drawn upon the motivational framework and evidence suggesting that threat and avoidance motivation have an impact on creative thinking (e.g., Higgins, 2000; Roskes et al., 2014), these processes were inferred, rather than directly tested. In other words, how our manipulation affected mood and goal setting was not measured. However, precisely the same manipulation increased anxiety in another research, consistently, on American and Polish samples (Karwowski et al., 2020). Nonetheless, measuring the affect would allow us to test the mediation model that could give a more reliable answer to our research question. Although theoretically, threat such as a pandemic, should increase motivation to avoid infection (and thus – prevention focus) and the fight against it is for most people rather passive (staying at home, avoiding contact with people), it cannot be ruled out that thinking of coronavirus activated thoughts about the loved ones or need to be close to them. In such a scenario, even the opposite – even approach motivation or challenge appraisal could have occurred. Testing the affect directly after manipulation would dispel such doubts.

5.1. Limitations and future directions

The study suffers from four main limitations that should make its interpretation cautious. First of all, the surprising and, therefore, interesting patterns of results were obtained in exploratory, non-preregistered analyses. Thus, rather than providing convincing conclusions as such, they should inspire researchers to build on them in future research. Second, the lack of affect assessment does not allow to confer the manipulation's effectiveness in eliciting threat. Third, as we mentioned, insight problem solving is neither the only, nor perfect way to measure creative thinking. Fourth and finally, the control condition priming participants with climate change news could have been arousing and qualified as a threat, just as the experimental condition. Still, however, while covid-19 brings serious and

direct consequences to individuals, climate change is less visible on an individual level as its consequences are indirect. One can get infected after contact with only one person (therefore regular daily activities become threatening), while implications of climate change, although being severe (Doherty & Clayton, 2011), are more blurred and perceptually less acute (Spence, Poortinga, & Pidgeon, 2012). Moreover, we emphasize that if control condition were not threatening at all, one could argue that any kind of threat would work in the same way, and the study would not bring any insight about the influence of covid-19-related information (see e.g., Liang, Zheng, Cheng, Zhou, & Liu, 2020). Ideally, our study should have included an additional, fully neutral condition to be able to both – conclude about a more general impact of threat on thinking and specific fashion in which coronavirus-related threats affect it.

The above-listed limitations suggest that it does not necessarily have to be the case that our hypothesis was not confirmed because it was invalid. Indeed, the theoretical background standing behind it seems robust and corroborated by several studies. However, other possibilities are present as well—for example, building upon studies showing that financial hardship occupies a fair share of cognitive resources and impedes cognitive functions (Mani, Mullainathan, Shafir, & Zhao, 2013), one could argue that having any serious reason to worry about, captures attention and diminishes cognitive control and performance in tasks requiring thinking. Therefore, insecurity and emergency, regardless of its source, may have affected both: analytical and insightful thinking through detriment in cognitive functions.

To sum up, although entirely unresponsive to a priori stated hypothesis and despite several limitations, our preregistered experiment contributes to the understanding of how coronavirus influences cognition. It not only shows that, for some reasons, men's performance in tasks requiring creative or analytical thinking is hampered after being exposed to information about coronavirus, but that they also seem to care less about the task at hand shortly after this exposure, which partly explains the mechanism behind this effect. Being aware of the fact that a pandemic may undermine our abilities and/or motivation to solve problems, we should think about how to minimize or gain resilience to this aversive effect. Moreover, individual differences in vulnerability to stressors or relative level of a stressor's saliency may moderate the relationship between stress/threat and creative cognition (Byron, Khazanchi, & Nazarian, 2010), and, to pave the roads to more effective coping strategies, these aspects should be addressed in future studies.

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CRedit authorship contribution statement

Maciej Karwowski: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing - original draft. **Agata Groyecka-Bernard:** Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Writing - original draft. **Marta Kowal:** Funding acquisition, Investigation, Writing - review & editing. **Piotr Sorokowski:** Funding acquisition, Investigation, Writing - review & editing.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.tsc.2020.100715>.

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