The Cost of Worrying about an Epidemic: Experimental Evidence on Labor Productivity during the COVID-19 Pandemic*

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Abstract

I conduct an online experiment to test whether negative emotional responses to the COVID-19 pandemic impair labor productivity. Subjects are exposed to a worry-amplifying or worry-alleviating media report before working on a cognitively demanding mental arithmetic task for a piece-rate wage. The treatment manipulation induces a multi-faceted negative emotional response, comprising an increase in worry and a decrease in happiness, but does not meaningfully reduce subsequent productivity. Nontheless, I find suggestive evidence of changes in cognition: exposure to the worry-amplifying media report increases relative interest in pandemic-related news and the reported incidence of distracting throughts during the task. One plausible interpretation for the combined set of results is that subjects compensate for worry-induced cognitive effects by increasing their mental effort, in line with the notion of income targeting. My findings indicate that exposure to information about the danger of COVID-19 does not have adverse side effects on economic productivity.

JEL classification: D91, J24, L82

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1 Introduction

A characteristic feature of human productivity is that it is responsive to short-term changes in psychological state. Consequently, productivity can tumble during emotionally challenging times. For instance, existing evidence points to productivity declines for individuals who experience personal tragedies like the unexpected death of a child (van den Berg, Lundborg, and Vikström, 2017) or the diagnosis of a severe disease (Liu and Zhu, 2014) as well as shocks to housing wealth during a recession (Bernstein, McQuade, and Townsend, 2021). Given the primary role of productivity in the economic system, changes in productivity can have far-reaching economic consequences. Productivity is linked to cross-country differences in economic prosperity, affects firm profitability and survival in market competition, and determines individuals' labor market outcomes (e.g., Hall and Jones, 1999; Foster, Haltiwanger, and Syverson, 2008; Lindqvist and Vestman, 2011). Therefore, preserving labor productivity during times of crisis is of crucial interest to policymakers, CEOs, and individuals alike.

This paper asks whether labor productivity is adversely affected by emotional responses to the COVID-19 pandemic, one of the greatest public health crises in history and a major source of emotional distress. This question has direct implications for the optimal structure of productivity-preserving work environments and optimal public communication during epidemics. A negative causal effect would suggest that continuous exposure to information about the danger of the disease comes at the cost of reduced economic productivity, implying a trade-off between the promotion of protective behavior and the intensity of the economic disruptions caused by the epidemic.

My main hypothesis is that worrying about the health consequences of an epidemic reduces labor productivity. It is based on studies from cognitive psychology, which indicate that worry can divert scarce attentional resources towards the perceived threat, thus reducing the available cognitive capacity for threat-unrelated processing tasks (Mathews, 1990; Eysenck, Derakshan, Santos, and Calvo, 2007; Robinson, Vytal, Cornwell, and Grillon, 2013; Moran, 2016; Sari, Koster, and Derakshan, 2017). Using field data from tests of cognitive ability during an episode of heightened public concern about Ebola in the US, Apenbrink (2021) provides evidence that this also applies to worrying about epidemic activity. Since most work tasks rely on cognitive skills, I expect the resulting short-term reductions in available cognitive function to impair labor productivity.[1] On the other hand, changes in cognitive function do not have to translate into changes of productivity. In contrast to many pure tests of cognitive ability, most real-life tasks also have an effort component. Thus, workers might be able to respond to a worry-induced reduction in available cognitive resources with a compensatory increase in mental effort.

To test the hypothesis, I conducted an online experiment with a student sample in autumn 2020, during the second wave of the COVID-19 pandemic in Germany. In the experiment, subjects can work on a cognitively demanding task that entails solving as many mental arithmetic problems as possible for a piece-rate wage. The task is divided into multiple five-minute blocks across two sessions on consecutive days, thus allowing to measure each subject's productivity and emotional state before and after introducing exogenous variation in emotional responses to COVID-19. Mental arithmetic resembles typical white-collar jobs in its reliance on both cognitive function and cognitive effort, making it an ideal task

[1] Existing research in economics suggests that concomitant other negative emotional responses like decreases in happiness could reduce productivity by means of similar cognitive processes (Kaufman, 1999; Oswald, Proto, and Sgroi, 2015).

for the purposes of my experiment. Moreover, subject performance on tasks involving mental arithmetic is found to be responsive to induced changes in emotions in previous experimental studies (e.g., Oswald, Proto, and Sgroi, 2015). The main treatment manipulation exposes participants to real media reports selected to either amplify or alleviate their worries about COVID-19. A comparison of subjects' number of correct answers in the subsequent blocks of the cognitive task across the two experimental conditions thus identifies the causal effect of worrying about COVID-19 on labor productivity.

My first finding is that the selected media reports provoke a strong multi-faceted emotional response. Relative to the other experimental condition, subjects' average reported level of worry about the health consequences of COVID-19 for themselves and their loved ones is about 0.7 scale points higher after watching the worry-amplifying news video, conditional on worry on the previous day. The worry response is accompanied by an even greater relative reduction in happiness of about 1.4 points on an 11-point scale. These results show that my treatment manipulation successfully introduces exogenous variation in subjects' emotional reactions, consistent with the conjecture that the COVID-19 pandemic is a major source of emotional distress.

However, the induced emotional responses do not translate into economically meaningful differences in labor productivity. My preferred estimates indicate that exposure to the worry-evoking news video reduces the number of correct answers on the cognitive task by 0.137, which is a decrease of about 1.1 percent relative to the mean of the condition with the worry-alleviating media report. The estimated treatment effect is not significantly different from zero and precise enough to comfortably rule out an effect size of 0.2 standard deviations (SD) at the five percent significance level. This conclusion is confirmed when testing for distributional effects ($p = 0.712$ in a Kolmogorov-Smirnov randomization test) or an association between changes in productivity and changes in emotional state. Moreover, I do not find treatment effects on secondary productivity outcomes connected to specific cognitive processes that underlie productivity on the task, like the error rate or the average number of seconds subjects spend thinking on a mental arithmetic problem before submitting an answer. There are also no meaningful differences in posttreatment productivity in subgroups that partition the sample by participants' general tendency to worry or reported COVID-19 media exposure, two characteristics that might indicate stronger responsiveness to the treatment manipulation.

I consider the possibility that an effect of worry on labor productivity may be masked or crowded out by unintended ancillary effects that arise from the treatment or the experimental design but are unrelated to worrying about COVID-19. First, I investigate whether the worry-amplifying news video motivates subjects to work harder by shifting their beliefs about the financial consequences of the pandemic, thus offsetting the effect of lower cognitive function. Similar effects are observed in a recent field experiment by Kaur, Mullainathan, Oh, and Schilbach (2021). I find that the treatment has no effect on subjects' concerns about their financial situation or job prospects and on their self-reported productivity goal for the cognitive task, thus effectively ruling out this alternative explanation. Second, I assess whether my conclusions might be affected by the possibility of cheating on the cognitive task, e.g., in the form of using a voice-controlled calculator. However, a high observed error rate, a negative relationship between improvements in answer speed and accuracy, and a better within-subject performance on relatively easier mental arithmetic problems suggest that widespread cheating is equally implausible.

Beyond identifying the general effect of epidemic-induced worrying on productivity, my experimental design also allows an exploratory test of whether the high salience of the pandemic in the media exacerbates this effect. In the last two task blocks of the second session, headlines and lead paragraphs of current news articles are displayed to subjects for a few seconds at random intervals between mental arithmetic problems. A secondary cross-randomized treatment manipulation varies whether subjects see headlines about COVID-19 or about unrelated neutral topics. Using a difference-in-differences approach, I can investigate whether the effect of worry on productivity changes when the pandemic is saliently featured in the news, while accounting for productivity effects of the displayed news headlines that are unrelated to worrying about COVID-19. As expected given the initial null result, the estimated coefficients are again close to zero and statistically insignificant.

Taking stock, my analyses provide no indication that negative emotional responses to the COVID-19 pandemic impair labor productivity. The intuition underlying my hypothesis suggests two potential explanations for this result: either worrying does not impede cognitive ability in my setting, or subjects compensate for worry-induced cognitive effects by increasing their mental effort, in line with the notion of income targeting (e.g., Fehr and Goette, 2007; Duong, Chu, and Yao, Forthcoming).

Two sets of additional analyses provide some suggestive evidence against the first and in favor of the latter explanation. First, by tracking participants' interest in the headlines displayed to them during the cognitive task, my experimental setting allows to test for changes in cognition directly. Comparing the relative propensity to save news articles about COVID-19 between subjects who were exposed to the worry-amplifying and worry-alleviating media report, I find evidence consistent with worry-induced attentional capture. Second, I analyze whether the main treatment manipulation affects subjects' self-assessments of their productivity. My estimates indicate that subjects are significantly more likely to report distracting thoughts after watching the worry-amplifying news video, consistent with the idea that subjects feel less productive because they have to exert more effort to accomplish the cognitive task. However, the estimated treatment effects on three other indicators of lower perceived productivity are not or only marginally significant. While I do not view these two pieces of evidence as conclusive, they provide some indication in favor of worry-induced changes in cognition that subjects make up for by means of increased cognitive effort. Therefore, this is my preferred interpretation of the results.

With respect to the external validity of my findings, it is important to keep in mind the timing of the experiment. In autumn 2020, when the experiment was conducted, eight months had passed since the start of the pandemic. Therefore, my results can only speak to the effects of emotional responses after individuals have had time to adapt to the situation rather than during the onset of an epidemic, which presumably comes with higher degrees of uncertainty and scope for stronger emotional turmoil.

My study belongs to a rapidly emerging literature on the economic effects of the COVID-19 pandemic, reviewed by Brodeur, Gray, Islam, and Bhuiyan (2021). Important focus areas of existing studies are the impact of government restrictions to contain the pandemic on various economic outcomes (e.g., Coibion, Gorodnichenko, and Weber, 2020; Sheridan, Andersen, Hansen, and Johannesen, 2020) and the supply and demand shocks caused by voluntary reductions in consumption and labor supply by agents who fear contracting the virus (e.g., Brynjolfsson, Horton, Ozimek, Rock, Sharma, et al., 2020; Chetty, Friedman, Hendren, Stepner, and The Opportunity Insights Team, 2020; Cox, Ganong, Noel, Vavra, Wong, et al., 2020; Eichenbaum, Rebelo, and Trabandt, 2021; Goolsbee and Syverson, 2021). Presumably due to limited data availability, there is less work on the effects of the pandemic on economic productivity. A number of studies investigate the impact of COVID-19 on academic research productivity on the basis of surveys and the quantity of working paper publications (e.g., Kruger, Maturana, and Nickerson, 2020; Barber, Jiang, Morse, Puri, Tookes, et al., 2021). Calculating changes in productivity from survey responses of UK firms, Bloom, Bunn, Mizen, Smietanka, and Thwaites (2020) estimate decreases in within-firm productivity that are partially offset by a between-firm increase in average productivity driven by output contractions in low-productivity sectors. However, the extent to which self-assessments and purely quantity-based measures of research output capture all relevant dimensions of productivity is unclear. The few studies with access to more objective metrics—either based on internal company analytics tools or on benchmarking moves of elite chess players against a powerful chess engine—focus on the effects of pandemic-induced shifts towards remote working, which seem to impair productivity in cognitively demanding occupations while improving it for call center workers (Emanuel and Harrington, 2021; Gibbs, Mengel, and Siemroth, 2021; Künn, Seel, and Zegners, 2022). My experiment also features an objective measure of productivity, but it differs from the aforementioned studies by isolating the labor productivity consequences of workers' psychological responses to the pandemic.[2] Methodologically, my use of a controlled experiment complements recent field studies that document a drop in output as a consequence of an epidemic without allowing to cleanly pin down the underlying causal channels (e.g., Correia, Luck, and Verner, 2020). Thereby, my findings contribute to an understanding of the specific mechanisms by which an epidemic disrupts (or does not disrupt) the economy, which is a prerequisite for the development of measures to effectively alleviate its adverse economic effects.

My study also relates to a literature on the economic effects of media exposure (e.g., DellaVigna and La Ferrara, 2015). The media plays an important role in times of crisis. By providing accurate, readily understandable, and timely information to a broad audience, it can keep the public informed about the newest developments and counteract the spread of misperceptions. As documented by Bursztyn, Rao, Roth, and Yanagizawa-Drott (2021) and Simonov, Sacher, Dubé, and Biswas (2022) in the context of the COVID-19 pandemic, media coverage can shape individuals' behavior and thereby affect the spread of the disease. On the other hand, both the framing and the sheer volume of media reporting can also propagate worry and fear. In text analyses of the media coverage of the COVID-19 pandemic in the US, Sacerdote, Sehgal, and Cook (2020) show that articles by major US news outlets are overwhelmingly negative in tone and choice of covered topics, irrespective of real-world epidemiological developments. Since my main experimental manipulation relies on real media reports that differ in both information content and framing, it poses a direct test of the effect of differences in media reporting. Consequently, my results speak to potential negative side effects of fear-evoking media reports during times of crises. My null result on productivity suggests that, holding labor supply fixed, reductions in economic productivity as a consequence of worry-inducing media reports are unlikely, at least when people have had time to get used to the situation. In contrast, the estimated negative effect on happiness implies a direct welfare cost of exposure to media about the pandemic, in line with arguments developed in Zeckhauser (1996) and recommendations of government agencies.[3] Moreover, my findings on worry-induced changes in cognition suggest that disease-related worry is one factor driving the demand for

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[2]Barber et al. (2021) document a correlation between health concerns and self-perceived productivity decline, but cannot establish a causal relationship because their data lack exogenous variation and the pandemic simultaneously affects several other determinants of productivity as well.

[3]On their webpage about coping with pandemic-induced stress, the US Centers for Disease Control and Prevention caution against constant consumption of news about the COVID-19 pandemic: https://www.cdc.gov/coronavirus/2019-ncov/daily-life-coping/managing-stress-anxiety.html.

pandemic-related news.[4] This could be an explanation for the predominantly pessimistic media coverage of the COVID-19 pandemic documented by Sacerdote, Sehgal, and Cook (2020).

Finally, I contribute to research on the effect of emotions on cognitive function and labor productivity. My experiment builds on and extends the results of Apenbrink (2021), who provides field evidence that worrying about the possibility of an epidemic impedes cognitive function more generally. I investigate the effect of worry in a different context—i.e., a different disease at a different point in the life cycle of epidemic activity, in a different sample, and with a different identification strategy—and focus on a specific economic outcome that might be affected by worry about epidemics. My findings qualify the economic significance of the cognitive effects of epidemic-induced emotions, implying that they either require levels of worry that are beyond the scope of an experimental manipulation or do not necessarily translate into reductions in labor productivity. As discussed in more detail in Section 5, this resonates with the results of related studies from behavioral development economics on the cognitive implications of financial strain, which seem to be more robust in settings with high uncertainty where strong worries are presumably more prevalent (e.g., Mani, Mullainathan, Shafir, and Zhao, 2013; Carvalho, Meier, and Wang, 2016; Lichand and Mani, 2020; Kaur, Mullainathan, et al., 2021). At the same time, my results contrast with the positive association between happiness and labor productivity documented by Oswald, Proto, and Sgroi (2015) in a similar experimental setup, again pointing to the importance of subtle situational factors. In particular, my findings suggest the possibility that the effect of changes in happiness on productivity might be stronger for increases than decreases or depend on the salience of a personal productivity goal.

The remainder of the paper is structured as follows. The details of the experimental design are described in Section 2, followed by an outline of the preregistered hypotheses and evaluation methods in Section 3. The results of the experiment are presented in Section 4. In Section 5, I discuss unaddressed threats to the internal validity of the study and how my findings can be reconciled with existing work on the effect of emotions on productivity. Finally, Section 6 concludes.

2 Experimental Design

An analysis of the effect of worrying about an epidemic on labor productivity requires (i) a clean measure of productivity on a task that is susceptible to cognitive distractions and (ii) exogenous variation in the level of worry. Importantly, the actual level of the epidemic has to be kept constant to avoid confounding the effect of the emotional response with the effect of the epidemic itself. For instance, an epidemic could also affect labor productivity by triggering avoidance behavior, changing opportunity costs of working, or due to direct health effects of the disease. Satisfying these requirements with observational data is difficult. Instead, I employ an online experiment in the context of the COVID-19 pandemic.

The online experiment consists of two sessions on two consecutive days. In each session, participants can work on a cognitively demanding task. The task is divided into multiple consecutive five-minute blocks during which participants are supposed to solve as many mental arithmetic problems

[4] For other studies on determinants of the demand for news during the COVID-19 pandemic, see Castriota, Delmastro, and Tonin (2020) and Faia, Fuster, Pezone, and Zafar (Forthcoming).

as they can for a piece-rate wage. The purpose of the first session is to obtain baseline measures of participants' productivity on the task as well as their self-reported level of worry about COVID-19 and momentary happiness. In the second session, I introduce exogenous variation in emotional responses to COVID-19 by showing subjects real media reports. The main treatment manipulation exposes subjects to a short news video clip about COVID-19 that is selected to either amplify (in condition *Worry-Amplifying*) or alleviate (in condition *Worry-Alleviating*) their worries about the pandemic. This is followed immediately by a second elicitation of worry and happiness that serves as a manipulation check. Afterwards, the mental arithmetic blocks of the second session begin. A cross-randomized second treatment manipulation is implemented while subjects are working on the cognitive task. During the last two blocks of arithmetic problems, subjects are exposed to headlines of current news articles that are either about COVID-19 (in subcondition *COVID-19 Headlines*) or about unrelated neutral topics (in subcondition *Neutral Headlines*) for a few seconds in between tasks. A comparison of subjects' performance on the task across the experimental conditions identifies whether fear-inducing media reports about the pandemic causally affect labor productivity and whether this effect is exacerbated by a high salience of the topic in the news.

The following subsections provide a detailed description of all components of the experimental design.

2.1 Cognitive Task

Participants' primary task throughout the experiment is to solve mental arithmetic problems. Each problem consists of adding and subtracting four two-digit numbers and includes one subtraction and two summation operations, as in the following example: $65 + 11 - 37 + 29$. The task is structured into blocks of five minutes, with short breaks between consecutive blocks. During each block, participants can work on the problems at their own pace and receive €0.10 for each correctly solved problem. The sequence of mental arithmetic problems within each block is the same for all subjects, and each block contains some easy and some more difficult problems by design.

This task is well-suited for the purposes of my study for a number of reasons. First, it relies heavily on a fundamental and ubiquitous cognitive function. Specifically, research from cognitive psychology suggests that solving mental arithmetic problems with multiple digits requires the interaction of all components of working memory (DeStefano and LeFevre, 2004). At the same time, working memory is an important ingredient to all real-life tasks that require individuals to at least temporarily store and manipulate information in mind. Second, and in contrast to many pure tests of cognitive ability, the mental arithmetic task also rewards cognitive effort. Such a combined requirement for cognitive ability and cognitive effort is typical for white-collar jobs and should therefore increase the generalizability to other cognitively demanding work tasks. Finally, it establishes comparability with previous experimental work on labor productivity, in which similar mental arithmetic tasks have been used. In particular, Oswald, Proto, and Sgroi (2015) show that exogenous increases in positive affect increase productivity on a mental arithmetic task, thus providing direct evidence that performance on the task is malleable in the context of changes in emotions.

One concern with implementing a mental arithmetic task—or any other cognitively demanding task—in an online experiment is that participants might cheat, e.g., by using a calculator. While it is not possible to fully prevent this,[5] the course of events for each arithmetic problem is designed to impede the most obvious forms of cheating: Each problem starts with a blank screen. After one, two, or three seconds, a blurred text appears. Participants can then display the unblurred arithmetic problem by simultaneously holding down the keys "Q" and "Enter" on their keyboard, thus preventing them from using their hands for other activities. As soon as they stop holding down "Q" and "Enter" or press any other key, the arithmetic problem is replaced by an input field, and participants have five seconds to type in their answer.[6]

Throughout the experiment, there are six blocks of mental arithmetic problems. Subjects complete two blocks of problems in the first session, which is identical in all experimental conditions. In these blocks, one mental arithmetic problem follows the other without interruption, in accordance with the above sequence of events. The purpose of the first block is to give subjects some experience with the task, whereas performance on the second block serves as a baseline measure of productivity. Of the four blocks in the second session, the first two, which I label "non-news blocks", are identical in structure to those in the first session. By contrast, the last two blocks have a slightly different structure that is explained in Section 2.3, along with the secondary treatment manipulation these blocks are designed to enable.

The primary outcome of interest is the average number of correctly solved mental arithmetic problems in the two non-news blocks of the second session. This is a measure of subjects' labor productivity after the main treatment manipulation. In addition, the structure of the task permits the measurement of three secondary productivity outcomes. The aim is to shed light on the effect of worry on specific cognitive processes that underlie subjects' productivity on the cognitive task.[7] First, the task is designed to reward attention. To complete as many problems as possible, subjects have to unblur each newly appearing problem without delay. Being less attentive has a cost in the form of wasted time, with the consequence that fewer problems can be attempted within a given block. I measure attention by computing an average reaction time, defined as the average number of seconds until participants press "Q" and "Enter" after the display of the blurred arithmetic problem, where the average is taken across all attempted problems during non-news blocks. Second, the task allows to construct two measures of working memory. As a measure for the time participants take for the mental calculation of their answers, I average the number of seconds the unblurred problem is displayed across all problems they attempt during non-news blocks. Moreover, the quality of answers is measured by the fraction of attempted problems in these blocks that are answered incorrectly. However, it is important to realize that the two measures of working memory are not independent because of the natural trade-off between accuracy and speed.

[5] For instance, subjects will always be able to work together in pairs, even though the instructions explicitly mandate working alone and the resulting effective hourly wage from pairing up would be quite low. I discuss indications of cheating in my data and whether this could plausibly affect my results in Section 5.1.

[6] Screenshots of the experimental interface for the cognitive task are provided in Figure E.1 in the appendix.

[7] Some of the secondary outcomes depend on the number of attempted mental arithmetic problems within one or multiple blocks. For this purpose, I define attempted problems as problems that are completed entirely within the five-minute time limit of the block, i.e., I discard data from problems during which the block time limit runs out before the input field for the answer disappears.

2.2 Main Experimental Conditions: *Worry-Amplifying* and *Worry-Alleviating*

To induce exogenous variation in the level of worry about the pandemic, I use real media reports about COVID-19 that differ in framing and information content. This provides a natural way to manipulate worry that combines the provision of factual information with differences in conveyed feelings and atmosphere. Compared to standard priming interventions, this also aims to provoke stronger emotional responses by shifting worry both upward and downward rather than only drawing attention to pre-existing concerns. At the same time, it also keeps the overall salience of the topic constant, thus permitting a manipulation check and a separate analysis of the additional effect of salience.

In the practical implementation, all subjects are randomly assigned to one of two main experimental conditions, with randomization conducted on the subject level. The assignment determines which of two short news video clips subjects watch at the beginning of the second session, before they start working on that session's four blocks of mental arithmetic problems. In particular, the clips are selected to either amplify or alleviate subjects' worries about the pandemic. The initial selection was conducted on the basis of an extensive screening of the media reporting about COVID-19 in Germany. The chosen videos were then tested in a small pilot experiment to ensure that they induce changes in worry in the study population.

The fear-evoking video is displayed to subjects in the *Worry-Amplifying* condition. It was produced by German public television broadcaster Bayerischer Rundfunk for their program *Frankenschau aktuell* on August 19, 2020, and deals with potential long-term health effects of a COVID-19 infection. It features the story of a 51-year-old man who barely survived a severe COVID-19 infection and suffered permanent neurological damage as a result of the disease. As a consequence, he now has to relearn basic everyday tasks like speaking, sitting, and walking even though he did not have any preconditions before the infection. This is conveyed vividly during a short interview with the patient, during which he struggles to articulate his words in a comprehensible manner and has to be subtitled. The video also includes comments by doctors who talk about the unpredictability of COVID-19 infections and the wide range of different long-term effects that have been observed, including heart, lung, and liver damage as well as neurological disorders. At the end, it is reported that about 10 percent of COVID-19 infections take a severe course.[8]

In contrast, subjects in the *Worry-Alleviating* condition are exposed to the fear-mitigating video, which is taken from the German public television news program *ZDF heute* from November 20, 2020. It is a report about the possibility that a COVID-19 vaccine could be approved for use in Europe within a few weeks. Moreover, it informs about the start of preparations for vaccination centers designed to enable a fast roll-out of vaccinations once a vaccine is approved. The video strikes a more optimistic tone and conveys the hope that a remedy for the pandemic is on the horizon.

A comparison of subjects' subsequent performance on the cognitive task across the two conditions identifies whether and how emotional responses to the pandemic causally affect labor productivity. To encourage participants to pay attention, I specify an unconditional payment of €4.00 for watching the video and announce that there will be an attention check in the form of a question about the video con-

[8] I cannot make the videos publicly available due to copyright issues. However, they are available to interested readers upon request.

tent afterwards. This appeals to subjects' reciprocity and allows screening out those who are inattentive nonetheless.

2.3 Secondary Experimental Conditions: *COVID-19 Headlines* and *Neutral Headlines*

To test whether the effect of worrying on labor productivity is exacerbated by the salience of the pandemic, I implement a cross-randomized secondary treatment manipulation. Whereas the main treatment manipulation induces exogenous variation in the level of fear about COVID-19, here the aim is to induce variation in the salience of the topic for a given level of worry. The underlying idea is that the effect of worrying about COVID-19 might linger longer if people frequently encounter the topic again, thus keeping the emotion top-of-mind.

To accommodate this in the experiment, I slightly adapt the structure of the cognitive task in the last part of the second session and expose subjects to additional media reports while working. This allows for an exploratory test without reducing statistical power for the main treatment manipulation. After subjects have completed the non-news blocks of mental arithmetic problems, which deliver the outcome data for the main treatment manipulation, the course of events for the individual mental arithmetic problems changes in the remaining two blocks of the task. In these blocks, which I call "news blocks", headlines and lead paragraphs of current online newspaper articles are displayed to subjects at random intervals between tasks for a period of 10 seconds. The net working time is unaffected by the number of headlines and remains at five minutes, so that productivity in news blocks can be measured analogously to productivity in the preceding blocks.

The secondary treatment manipulation determines what kind of articles subjects are exposed to while working. Within each of the two main experimental conditions, subjects are randomized into one of two secondary experimental conditions, *COVID-19 Headlines* or *Neutral Headlines*, with equal probability. Subjects in the *COVID-19 Headlines* subcondition see headlines of articles about COVID-19. In contrast, subjects in the *Neutral Headlines* subcondition see headlines of articles from a wide range of neutral topics like science, sports, entertainment, politics, and economics. Importantly, all articles in this condition are unrelated to the COVID-19 pandemic. These are articles that people would encounter if there was no pandemic or if it was less prominently featured in the news. This choice of control group ensures that differences in productivity across secondary experimental conditions for a given realization of the main treatment manipulation are driven by the topic of article headlines. Any general distraction effect of being exposed to news headlines while working, which could be specific to one's emotional state, applies equally to both secondary conditions.

All articles are collected at around 5:00 in the morning on the day of the second session, so most of the headlines concern the previous day. To compile potential articles, I use a news aggregator of popular German news websites, including Bild.de, Die Welt, FAZ.net, Handelsblatt, n-tv.de, Spiegel Online, Süddeutsche.de, and t-online.de. All subjects within a secondary condition that participate in the experiment on the same day see the same articles at the same point in the sequence of arithmetic problems. On average, subjects are shown an article headline every second time they have entered an answer for a mental arithmetic problem. The random component in the display of news headlines implies that they cannot avoid paying attention to the headlines if they want to complete as many arithmetic problems as possible within the time limit.

2.4 Elicitation of Additional Outcomes

To complement the productivity measures and allow a suggestive exploration of the underlying mechanisms of a potential treatment effect, I gather some additional outcomes throughout the experiment.

Measures of worry and happiness. I elicit measures of two emotions through which the main treatment manipulation might reduce productivity: worry and happiness. In particular, subjects are asked for self-reports of their level of worry about the health consequences of COVID-19 for themselves and their loved ones as well as their level of momentary happiness. Both measures are elicited using a Likert scale response format with an 11-point scale from 0 to 10. They are collected twice throughout the experiment, once at baseline at the beginning of the first session, and once just after the main treatment manipulation. Since the items are presented as numbers with two defined endpoints and many intermediate values, I interpret the resulting responses as approximating interval data. The collected data permits a manipulation check to assess whether the main treatment manipulation indeed increases subjects' degree of worry about the pandemic. Moreover, it reveals whether potential treatment effects should be interpreted as purely driven by worry or as the joint effect of a multi-faceted emotional response.

News interest. While my main interest is in the reduced-form effect of emotions on labor productivity, my experimental design also permits a direct test of the hypothesized underlying changes in cognition. A common perception regarding the cognition effects of worry in both psychology and economics is that scarce cognitive resources are redirected towards the object of concern, thus reducing their availability for other tasks (e.g. Eysenck et al., 2007; Mullainathan and Shafir, 2013; Lichand and Mani, 2020).

To allow for a test of this idea in the context of my experiment, I collect a behavioral measure of news interest. Subjects can click on the article headlines displayed to them during news blocks of the cognitive task to save them at no cost. Only saved articles are displayed again at the end of the experiment, so that subjects can read them afterwards. The underlying idea is that headlines about COVID-19 may capture subjects' attention even though they want to remain concentrated for the upcoming mental arithmetic problem, and this attentional shift is revealed in the action of saving the article for later reading. Since, for various reasons, instances of attentional capture may be too weak to induce subjects to save an article, I interpret this as a measure of how interested subjects are in the respective news topic relative to their focus on the task. This is a stronger notion of cognitive resource reallocation than a simple shift in attention. Of course, saving an article can also be interpreted simply as a demand for news about the respective topic.

Perceived productivity. I also elicit subjects' satisfaction with their performance on the task and their perceptions of their own productivity. Satisfaction with own performance in the second session is elicited on an 11-point scale. To get a sense of perceived productivity, subjects are asked to guess whether they have solved more, about the same, or fewer tasks in the second session relative to baseline. Guesses are elicited separately for non-news blocks and news blocks. The resulting data can be used to check whether subjects underestimate of overestimate the effect of media reports on productivity.

Beliefs about COVID-19. The postexperimental questionnaire elicits beliefs about COVID-19 that might be affected by the news videos. In particular, I elicit probabilistic beliefs about the risk of infection, the risk of long-term health effects conditional on infection, and the risk of death conditional on infection for inhabitants of Germany within the next six months. In addition, I also ask subjects to provide a best guess of the number of months until a vaccine becomes widely available in Germany.

Other outcomes. Finally, I elicit a few other outcomes designed to assess the plausibility of alternative explanations or permit heterogeneity analyses. After the main treatment manipulation, but before subjects start working, I ask them for their goal number of correct answers for the second session. In the postexperimental questionnaire, I elicit two measures of worry about the personal financial consequences of the pandemic, also on 11-point scales, and two items from validated survey measures of positive and negative reciprocity developed by Falk, Becker, Dohmen, Huffman, and Sunde (2016). Moreover, I include the German version of the Penn State Worry Questionnaire (PSWQ), which measures an excessive tendency to worry using 16 items (Meyer, Miller, Metzger, and Borkovec, 1990; Glöckner-Rist and Rist, 2014).

2.5 Procedures

The experiment was programmed in oTree (Chen, Schonger, and Wickens, 2016) and conducted online with subjects from the pool of the BonnEconLab. A total of 305 subjects participated in three iterations of the experiment that were spread out over a period of two weeks in late November and early December of 2020. At this time, Germany was in the midst of the second wave of the pandemic and experienced a continuously high number of daily new COVID-19 cases despite containment measures. The first vaccine manufacturers had just published encouraging results from clinical trials, but no vaccine had been authorized for use yet in the European Union and the US, so there remained some uncertainty about the start of vaccination campaigns. However, eight months had passed since the declaration of a national epidemic in Germany, implying that people had had ample time to adapt to the existence of the virus.

The subject pool of the BonnEconLab mainly consists of university students.[9] While students face a low risk of suffering a severe course of COVID-19 because of their young age, surveys indicate that they had similar levels of worry about the pandemic at the time of the experiment. The reason is that their rationally lower propensity to worry about their own health is offset by more pronounced concerns about family and friends. Computing the fraction of respondents who report high or very high levels of worry in at least one of these two dimensions in a nationally representative German survey at the end of November (Presse- und Informationsamt der Bundesregierung, Berlin, 2021), I find that 63.5 percent of respondents below 30 years of age are classified as worried, compared to 58.4 percent of respondents aged 30 or older. Taking into account the importance of worry about others in the subject pool, my study explicitly concerns worry about the health consequences of COVID-19 both for subjects' themselves and for their loved ones.

[9] See Snowberg and Yariv (2021) for a recent study on the external validity of economic experiments with student populations relative to representative samples. A main finding is that comparative statics are very similar across different participant pools.

The chronology of the main components of the experimental design is visualized in Figure 1. Subjects were invited for a two-session online experiment using hroot (Bock, Baetge, and Nicklisch, 2014). On the day of the first session, registered participants were sent a unique link by e-mail early in the morning and had time until midnight to complete the first part of the experiment. The first session started with the elicitation of subjects' sociodemographic characteristics and baseline measures of worry about COVID-19 and momentary happiness. Afterwards, participants received instructions about the cognitive task.[10] To check their understanding, they had to answer a set of comprehension questions. The questions also tested whether their device satisfied the technical requirements for the task.[11] As the last component of the first session, subjects completed two blocks of mental arithmetic problems.

Procedures for the second session were similar. Again, subjects received their unique link early in the morning and could start the session at their own pace, as long as they finished until the end of the day. First, they read the instructions for the second session and completed comprehension questions. Second, they watched the news video clip of their experimental condition and answered the attention-check question about it, followed by the manipulation check. Then, they completed the two non-news blocks of arithmetic problems, followed by an elicitation of perceived productivity for these two blocks. Afterwards, they worked on the two news blocks of the cognitive task, during which they were presented with news headlines according to their experimental condition. Finally, they completed a short questionnaire.

Since treatment-induced worry might fade over time, an important aim of the experimental procedures and instructions for the second session is to minimize the time gap between the main treatment manipulation and the cognitive task. In particular, (i) subjects are told at the beginning of the second session that they have to complete it without interruptions, (ii) instructions and comprehension questions for all parts of the second session are scheduled before the treatment manipulation, (iii) a pop-up window prompts subjects to continue with the experiment if they take longer than three minutes for the manipulation check between the news video clip and the cognitive task, and (iv) the first block of mental arithmetic problems starts automatically once subjects have completed the manipulation check.[12]

3 Preregistered Hypotheses and Analyses

My experiment is designed to facilitate tests of three main hypotheses relating to the effect of worrying about COVID-19 on labor productivity. All hypotheses are preregistered in a pre-analysis plan that was uploaded to the AEA RCT Registry before the start of the experiment. The preregistration documents are accessible in the registry under identifying number AEARCTR-0006558.[13]

[10]An English translation of the instructions for both sessions of the experiment is provided in Appendix D.

[11]Subjects could not proceed to the next page of the experiment until all comprehension questions were answered correctly. If they made a mistake, they were told to reread the instructions and try again, without receiving feedback which questions were answered incorrectly. Thus, the probability that participants passed the comprehension questions by trial and error is very low.

[12]An analysis of participants' response times shows that these measures were successful: 91.8 percent of subjects spend less than 60 seconds longer than the video clip duration on the video page, and 98.5 percent of subjects spend less than three minutes on the manipulation check, i.e., less than 60 seconds per question.

[13]The names of the experimental conditions were changed after running the experiment. The preregistration documents still contain the old condition names. The main experimental conditions were previously called *High concern* and *Low concern* instead of *Worry-Amplifying* and *Worry-Alleviating*, while the secondary conditions were called *High news salience* and *Low news salience* in place of *COVID-19 Headlines* and *Neutral Headlines*.

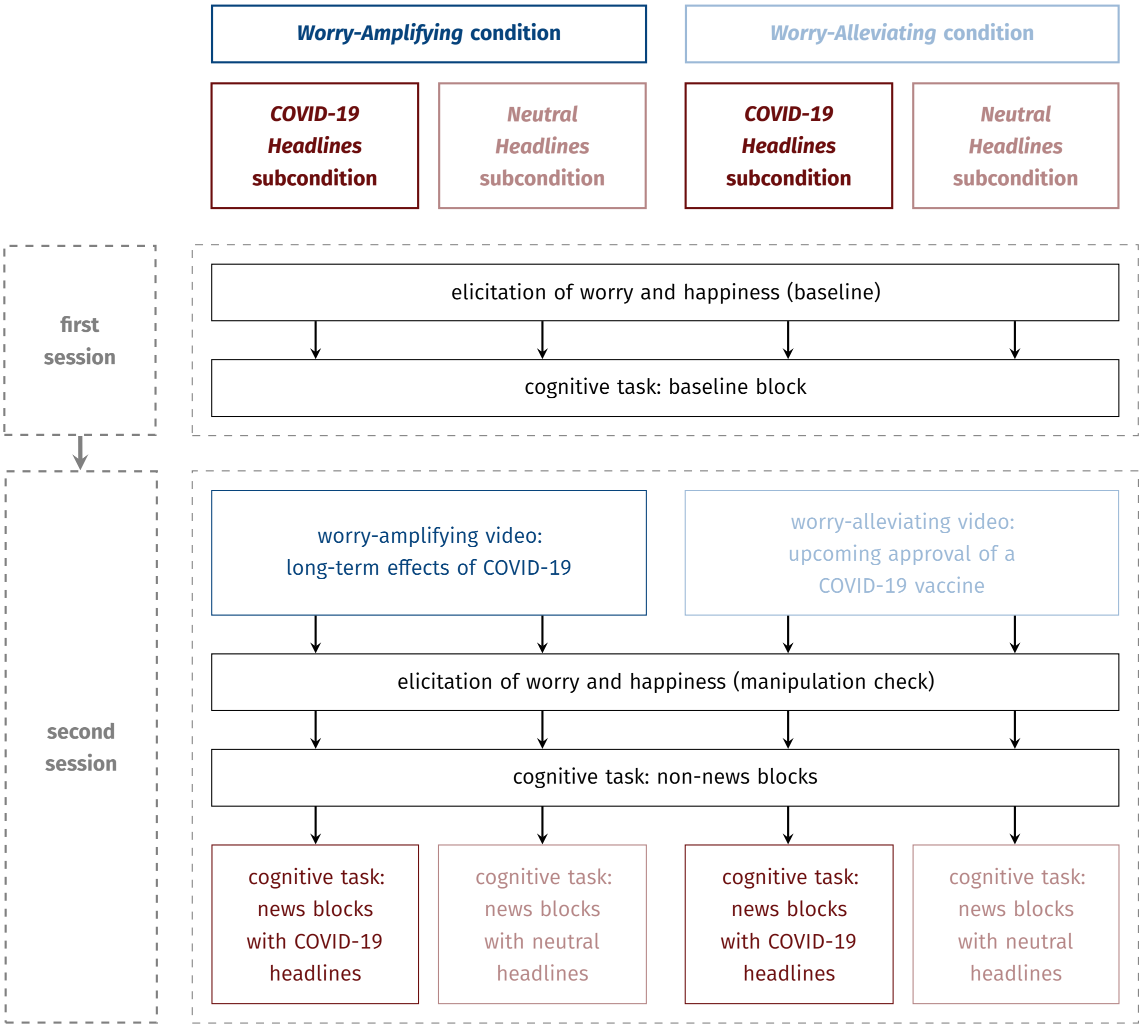

Figure 1. Chronology of the Main Components of the Experimental Design by Experimental Condition

Notes: Timeline of the most important components of the experimental design. For each combination of main and secondary experimental conditions, arrows indicate the sequence of experimental components. Sets of components that belong to the same session are framed by dashed gray rectangles. Within each session, experimental components that are identical in all conditions are drawn in black and span the whole width of the respective dashed rectangle. Components that differ between conditions *Worry-Amplifying* and *Worry-Alleviating*, constituting the main treatment manipulation, are highlighted in dark and light blue, respectively, whereas components that differ between the *COVID-19 Headlines* and *Neutral Headlines* subconditions are colored in dark and light red.

As explained in the pre-analysis plan, all analyses are conducted using subject-level ordinary least squares (OLS) regressions with robust standard errors if not otherwise specified. Whenever possible, I control for the respective outcome measure at baseline to increase statistical power. For task outcomes, this is defined as the respective outcome in the second mental arithmetic block of the first session. I intentionally do not use data from the first block because this is the first time participants try out the task, so I expect additional noise in this data. Covariates are centered around the sample mean for continuous variables and around the sample median for non-binary discrete variables to facilitate interpretation of the constant. For most analyses, this implies estimation equations of the form

$$Y_i \;=\; \alpha + \beta \, \textit{Worry-Amplifying}_i + \gamma' \boldsymbol{X}_i + \epsilon_i, \tag{1}$$

where Y_i is the outcome of interest for subject i, *Worry-Amplifying*$_i$ is an indicator equal to one if subject i is in the *Worry-Amplifying* condition, and $\boldsymbol{X}_i$ is a vector of control variables that contains the respective baseline outcome and may include additional covariates. The coefficient of interest is β.

3.1 Primary Hypotheses

The first hypothesis concerns the effect of the main treatment manipulation on subjects' level of worry about the health consequences of COVID-19 and constitutes a manipulation check. I expect that the main treatment manipulation shifts subjects' worry about COVID-19. This is a prerequisite for all subsequent analyses.

Hypothesis 1. *The level of worry about the health consequences of COVID-19 for oneself and one's loved ones is higher in condition Worry-Amplifying than in condition Worry-Alleviating.*

Since worry is not an isolated emotional response, it could be accompanied by other negative emotions. To assess the extent to which changes in productivity should be interpreted as the effect of worry in particular or as the effect of negative emotional responses to epidemics more generally, I also check whether the video affects feelings of happiness.

My main hypothesis concerns the effect of worrying on labor productivity. It is based on studies from cognitive psychology, which indicate that worrying can divert scarce attentional resources towards the perceived threat, thus reducing the available cognitive capacity for threat-unrelated processing tasks (Mathews, 1990; Eysenck et al., 2007; Robinson et al., 2013; Moran, 2016; Sari, Koster, and Derakshan, 2017). Intuitively, intrusive thoughts of worry can induce cognitive load in the same way as external distractions like a honking car or an overheard conversation. In line with this mental model, subjects exposed to the worry-evoking video clip should experience short-term reductions in their cognitive function that decrease their labor productivity for a given level of effort. To the extent that the emotional response to the video also includes a reduction in happiness, the effect of happiness on productivity documented in Oswald, Proto, and Sgroi (2015) suggests a complementary dynamic.[14]

Hypothesis 2. *Labor productivity, measured as the average number of correctly solved mental arithmetic problems across non-news blocks, is lower in condition Worry-Amplifying than in condition Worry-Alleviating.*

The intuition behind Hypothesis 2 also clarifies that there are two contingencies under which it might be untrue: (i) if worrying does not affect cognitive function in the current setting, e.g., because it is context-specific and subjects have already adapted to COVID-19 eight months into the pandemic, or (ii) if subjects compensate for the cognitive effects of worrying by putting in more mental effort, e.g., because they want to attain a goal number of correct answers that serves as a salient reference point or an income target (e.g., Heath, Larrick, and Wu, 1999; Fehr and Goette, 2007).[15]

[14] I do not attempt to draw a conceptual distinction between the cognitive processes behind the productivity effects of changes in worry and happiness. In fact, Oswald, Proto, and Sgroi (2015) mention the possibility that increases in happiness free up cognitive resources otherwise captured by worrying on everyday problems as one potential mechanism behind their findings. Moreover, I do not take a stance on or investigate empirically to what extent these emotional responses and the resulting cognitive effects are productive in other ways, e.g., by increasing the chances of surviving the threat or providing some sort of catharsis for one's anxiety.

[15] A review of the current state of research on the role of reference dependence for effort choices is provided by Goette (2021). Most relevant to my setting are studies that document increases in effort for individuals at risk of falling short of a personal goal.

Lastly, I hypothesize that the effect of worry on labor productivity is exacerbated by a continued salience of the pandemic in news headlines. The underlying intuition is that worry-induced distractions are temporary: even for individuals who are very scared of the disease, there will be phases during which worry fades and the mind can focus on the task. I expect that continued salience of the pandemic prevents this by keeping worry top-of-mind.[16] However, this hypothesis should be viewed as exploratory because my sample size is not large enough to draw a firm conclusion about it.

Hypothesis 3. *The negative effect of the Worry-Amplifying condition on labor productivity is stronger in subcondition COVID-19 Headlines than in subcondition Neutral Headlines.*

To test Hypothesis 3, I augment Equation 1 by two additional regressors and estimate a difference-in-differences equation. In particular, I regress productivity in news blocks on indicators for the *Worry-Amplifying* condition, the *COVID-19 Headlines* subcondition, and their interaction, controlling for baseline productivity. My hypothesis corresponds to a negative coefficient on the interaction term.

3.2 Other Preregistered Analyses

I also preregistered a number of additional analyses to gather supporting evidence and learn more about the determinants of the hypothesized relationships. I briefly summarize these analyses here.

(1) I test for an effect of the main treatment manipulation on subjects' beliefs about the danger of COVID-19. If the news video clips affected worry by shifting beliefs rather than conveying feelings, I would expect beliefs to differ across the two main experimental conditions.

(2) I assess the evolution of the main treatment effect over time within the four mental arithmetic blocks of the second session, focusing on participants in the *Neutral Headlines* subcondition.

(3) I test for an adverse effect of the main treatment manipulation on three measures of specific cognitive processes that determine productivity on the cognitive task: reaction time to the appearance of new mental arithmetic problems, calculation time per problem, and error rate.

(4) I investigate whether greater changes in worry or happiness in response to the main treatment manipulation are associated with greater reductions in productivity relative to baseline.

(5) I conduct heterogeneity analyses with respect to PSWQ score and self-reported exposure to media coverage about the pandemic. I expect a stronger effect for participants with a greater tendency to worry. I do not have a prior expectation regarding the heterogeneous effect for participants who

For instance, marathon runners increase their pace at the end of the race if they would otherwise just miss a round finishing time like the four-hour mark (Allen, Dechow, Pope, and Wu, 2017) and report reduced satisfaction if they fail to stay within their stated time goal (Markle, Wu, White, and Sackett, 2018). Moreover, bicycle taxi drivers in Kenya work more on days on which they report higher cash needs (Dupas, Robinson, and Saavedra, 2020), and Singaporean taxi drivers respond to unexpected booking cancellations or passenger no-shows by increasing their subsequent work productivity to offset the loss in earnings (Duong, Chu, and Yao, Forthcoming).

[16] Mullainathan and Shafir (2013, chapter 2) report the results of a related experiment that illustrates how everyday cues can trigger scarcity-induced distractions. In their experiment, they compare the performance of dieters and non-dieters on a word search task with a neutral word (e.g., "cloud") after either having done a word search task with a tempting word (e.g., "cake") or a neutral word (e.g., "street") just before. They find that dieters on average take 30 percent longer to find the identical neutral word if the preceding task included a tempting word, whereas there is no effect for non-dieters. Interpreting this result, they argue that the tempting word brings a pre-existing longing for food top-of-mind, which then continues to capture subjects' attention and distracts them also on the next temptation-unrelated task.

follow the news about COVID-19. On the one hand, this could indicate less scope for the treatment to shift participants' level of worry, happiness and beliefs. On the other hand, those most concerned about the pandemic could be more likely to follow the news about it.

(6) I look for direct evidence that the main treatment manipulation has cognitive effects by testing for selective attention to pandemic-related news articles. In particular, I regress measures of news interest on indicators for the *Worry-Amplifying* condition, the *COVID-19 Headlines* subcondition, and their interaction. I control for the number of attempted tasks at baseline to proxy for the number of headlines participants see during the two news blocks of the task. I expect a positive coefficient on the interaction term, indicating that worried participants show a greater interest in news about the pandemic as compared to neutral news.

4 Results

Of the total number of 305 participants, 279 completed both sessions of the experiment.[17] Attrition is mostly driven by subjects whose devices did not satisfy the technical requirements for the task and subjects who did not show up to the second session. No subject dropped out after the main treatment manipulation, so differential attrition is not a concern. In line with the pre-analysis plan, five subjects were excluded from the sample because they did not pass the attention check after watching the video clip and six more were excluded because they did not solve a single mental arithmetic problems in at least one block, resulting in a final analysis sample of 268 subjects.

In the following, I first report baseline sample characteristics and show that the main treatment manipulation successfully shifted subjects' emotional responses to the COVID-19 pandemic. Then, I present results on the effect of the two treatment manipulations on labor productivity, in accordance with the hypotheses outlined in Section 3. Afterwards, I report suggestive evidence of changes in cognition and perceived productivity in response to the main treatment manipulation.

4.1 Baseline Sample Characteristics

Descriptive statistics for the analysis sample are reported in Table A.1. One noteworthy observation is the relatively high average degree of worry at baseline, with a mean of 6.1 and a median of 7 on a scale from 0 to 10. This is reassuring because it implies that the vast majority of my student sample is sufficiently concerned about COVID-19 to respond to my experimental manipulations.

Table A.2 presents baseline sample characteristics by main experimental condition. In addition to the mean and SD, I also report the standardized difference of means between the two conditions, defined as the difference in means normalized by the pooled sample SD. As expected given randomization, the sample means of most baseline variables are not meaningfully different across conditions. However, the baseline level of worry in the *Worry-Amplifying* condition is almost 0.7 scale points lower than that in the *Worry-Alleviating* condition, corresponding to a standardized difference of means of 0.28 SD. Since this

[17] This includes two subjects who chose not to provide their bank details and therefore could not receive their payment despite finishing the experiment.

imbalance seems large enough to potentially distort some of my results, I additionally present estimates from specifications which control for baseline worry for all statistical analyses reported in the main text, even if this is not specified in the pre-analysis plan.

4.2 Manipulation Check: Emotional Responses to the Main Treatment Manipulation

Before turning to the effect of the experimental manipulations on labor productivity, I first check whether the main treatment manipulation succeeded in changing participants' emotional response to COVID-19, in line with Hypothesis 1. The coefficient estimates of this manipulation check are displayed in Table 1.

Table 1. Manipulation Check: Effect of the Main Treatment Manipulation on Worry and Happiness

Dependent variable:	Change in worry	Worry		Change in happiness	Happiness	
	(1)	(2)	(3)	(4)	(5)	(6)
Worry-Amplifying condition	0.819***	0.152	0.731***	−1.473***	−1.405***	−1.446***
	(0.142)	(0.286)	(0.135)	(0.224)	(0.247)	(0.201)
Worry at baseline (cent.)			0.868***			
			(0.032)			
Happiness at baseline (cent.)						0.592***
						(0.063)
Constant	−0.083	6.348***	6.842***	0.341**	6.530***	7.010***
	(0.079)	(0.198)	(0.079)	(0.154)	(0.164)	(0.119)
Observations	268	268	268	268	268	268
R^2 (adjusted)	0.107	−0.003	0.765	0.137	0.105	0.403
Mean (dependent variable)	0.332	6.425	6.425	−0.407	5.817	5.817

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. *Worry-Amplifying condition* is an indicator equal to one for subjects in the experimental condition of the same name. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

In column (1), the dependent variable is the change in worry from baseline to after the news video clip. On average, there is a significant increase in worry in the *Worry-Amplifying* condition of about 0.8 scale points, while the decrease in worry in the *Worry-Alleviating* condition is small and insignificant. This suggests that the main treatment manipulation successfully shifted subjects' worry about COVID-19, and this was driven by the worry-inducing video clip.

In columns (2) and (3), I test whether the differential shift in worry after the treatment manipulation translates into level differences across the two conditions, once without and once with adjustment for worry at baseline. The raw difference in average posttreatment worry across the two conditions is small and insignificant. This is attributable to the baseline imbalance: the increase in worry in the *Worry-Amplifying* condition closes the initial gap between the two conditions rather than opening up a new one. The preregistered specification in column (3) controls for baseline worry and therefore accounts for the baseline imbalance. In this specification, the worry gap between the two conditions increases to about

0.7 scale points, which is highly significant and captures about 80 percent of the treatment-induced change in worry from the first to the second session estimated in column (1).

All in all, these estimates provide support for Hypothesis 1. As long as the initial imbalance is accounted for by controlling for worry at baseline, participants in the *Worry-Amplifying* condition exhibit an exogenously higher level of worry compared to those in the *Worry-Alleviating* condition, driven by a large increase in worry in the second session. In Appendix B, I investigate whether the shift in worry is driven by new factual information contained in the video clips or by the communicated feelings and emotions. For this purpose, I estimate the effect of the main treatment manipulation on elicited beliefs about the virus. The identified pattern of belief shifts suggests that the effect is at least partly driven by conveyed emotions rather than information provision.

The remaining columns contain analogous coefficient estimates for happiness. This reveals whether the increase in worry is accompanied by a reduction in happiness, which could trigger complementary—though presumably conceptually similar—cognitive processes through which epidemic-induced emotions impair productivity. The estimates show a gap in happiness of about 1.4 scale points between conditions *Worry-Amplifying* and *Worry-Alleviating* after the main treatment manipulation, which is mainly driven by a large decrease in happiness following the worry-evoking video. This implies that the results in the subsequent subsections should be interpreted as the joint effect of a multi-faceted negative emotional response to the pandemic.

4.3 Effect of the Main Treatment Manipulation on Labor Productivity

In Table 2, I present coefficient estimates from tests of Hypothesis 2, which predicts that labor productivity decreases after watching the worry-inducing news clip about COVID-19. The dependent variable is the average number of correct answers across the two non-news blocks of mental arithmetic problems, before the start of the secondary treatment manipulation. I report three specifications which differ in the included covariates. The regression results offer no evidence that the main treatment manipulation affects productivity. The point estimate of my preferred specification in column (3), which controls for both worry and productivity at baseline, indicates that exposure to the fear-evoking video causes a drop in the number of correct answers of 0.137. Relative to the mean of the *Worry-Alleviating* condition, this is a decrease of about 1.1 percent. The estimated treatment effect is far from significant in both statistical and economic terms as well as reasonably precise. In particular, I can comfortably rule out a 0.2 SD effect at the five percent significance level.[18]

Table C.1 in Appendix C reports estimates from alternative specifications that also include demographic control variables or account for baseline emotions nonlinearly. The estimated treatment effect is slightly greater in absolute size in some of these specifications, ranging up to −0.268. However, it always remains statistically insignificant and economically small. In light of the documented baseline imbalance in worry, it is especially reassuring that the inclusion of a set of dummies for the possible values of baseline worry does not substantially change the results.

[18]The partitioning of the cognitive task into blocks with independent sequences of mental arithmetic problems within each block also permits an investigation the evolution of the treatment effect over time. Figure A.1 in Appendix A plots separate coefficient estimates of the main treatment effect for each block of mental arithmetic problems of the second session. Although the coefficient for the first block is slightly greater in absolute size, none of the estimates is significantly different from zero.

Table 2. Effect of the Main Treatment Manipulation on Labor Productivity in Non-news Blocks

	Dependent variable: Correct answers per non-news block		
	(1)	(2)	(3)
Worry-Amplifying condition	0.069	−0.069	−0.137
	(0.478)	(0.280)	(0.286)
Correct answers at baseline (cent.)		0.799***	0.791***
		(0.033)	(0.033)
Worry at baseline (cent.)			−0.105
			(0.065)
Constant	12.023***	11.326***	11.274***
	(0.342)	(0.193)	(0.201)
Observations	268	268	268
R^2 (adjusted)	−0.004	0.657	0.660
Mean (dependent variable)	12.058	12.058	12.058

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. *Worry-Amplifying condition* is an indicator equal to one for subjects in the experimental condition of the same name. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

The regression results in Table 2 show that the main treatment manipulation does not have an effect on productivity on average, but they might not reveal more general distributional effects. Therefore, Figure 2 additionally plots the empirical cumulative distribution of labor productivity by main experimental condition, once before and once after adjusting for covariates. The resulting distributions look similar in both panels of the figure. To assess formally whether there are significant differences in the shape of the outcome distribution across conditions, I conduct Kolmogorov-Smirnov tests. Since the standard version of the test suffers from low statistical power in the presence of ties in the data, I use a randomization test with 10 000 repetitions to compute the *p*-values manually (Neuhäuser, Welz, and Ruxton, 2017). The underlying idea is that under the null hypothesis that the treatment effect is zero for all subjects, the value of the Kolmogorov-Smirnov test statistic should be unaffected by random permutations of participants' treatment status. To obtain a *p*-value, I compare the observed value of the Kolmogorov-Smirnov test statistic to the randomization distribution of test statistic values that emerges from reshuffling treatment status and recalculating the test statistic a large number of times. An observed value of the test statistic in the tails of the randomization distribution is evidence against the null hypothesis. Rosenbaum (2002) shows that randomization inference can also be applied to covariate-adjusted outcomes. The resulting *p*-values of the Kolmogorov-Smirnov randomization tests are 0.809 and 0.712 for the raw and covariate-adjusted outcome distributions, respectively. Thus, I cannot reject the null hypothesis that the distribution of labor productivity is the same in both experimental conditions.

I also test whether the main treatment manipulation affects measures of attention and working memory, two specific cognitive processes that determine productivity on the cognitive task. The respective coefficient estimates are reported in Table A.3 and Table A.4 in Appendix A.[19] In line with the above results for the primary productivity measure, the estimates provide no evidence that watching the fear-

[19] Cumulative distribution plots for the individual cognitive processes can be found in Figure A.2 and Figure A.3.

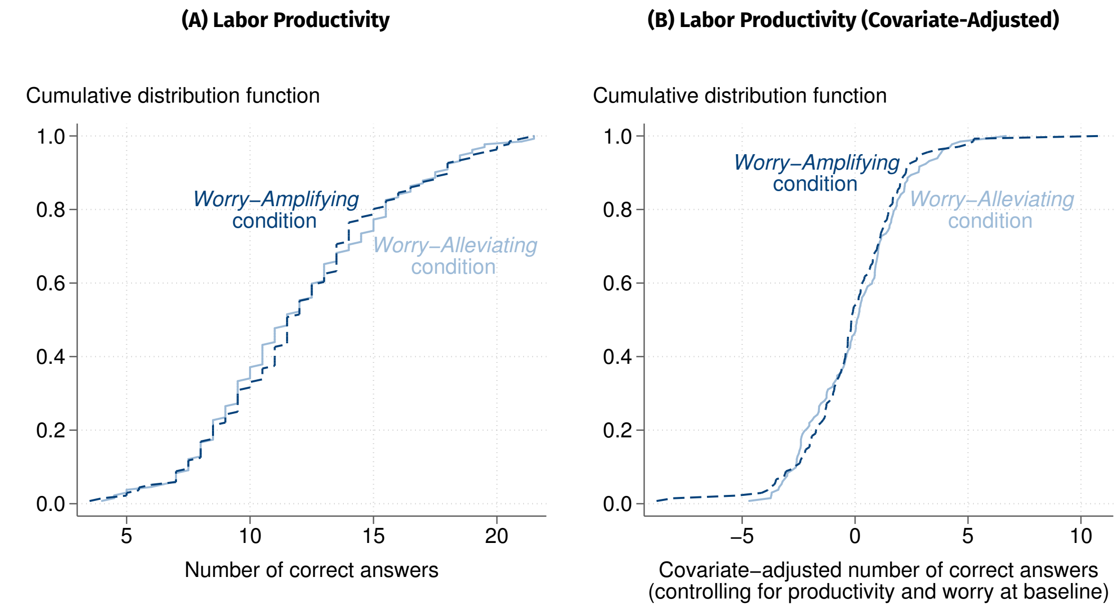

Figure 2. Labor Productivity in Non-news Blocks by Experimental Condition

Notes: The cumulative distribution of labor productivity in non-news blocks, plotted separately for subjects in the *Worry-Amplifying* condition (dashed dark blue line) and the *Worry-Alleviating* condition (solid light blue line). Panel (A) shows the distribution of the average number of correct answers across the two non-news blocks of mental arithmetic problems. Panel (B) shows the distribution of the residuals from a regression of the average number of correct answers on the baseline number of correct answers and the baseline level of worry.

evoking video has an impact on subjects' reaction time to the appearance of new mental arithmetic problems, their average calculation time per problem, or their error rate.

Next, I investigate the relationship between within-subject changes in productivity and changes in emotional state. If productivity is impaired by negative emotional reactions to COVID-19, then subjects with stronger emotional responses to the main treatment manipulation should experience greater decreases in productivity in non-news blocks relative to baseline. Table 3 contains estimates from regressions of changes in productivity on changes in worry and happiness.[20] All point estimates are close to zero and far from statistically significant, indicating that there is no association between treatment-induced changes in emotional state and changes in productivity.

Even if the treatment has no meaningful average effect in the full sample, it could still influence the labor productivity of especially susceptible subgroups. Two such subgroups were specified in the pre-analysis plan. First, I expect subjects with a higher tendency to worry, as revealed by a higher PSWQ score, to respond more strongly to the treatment manipulation. Second, one might expect differential effects by subjects' level of attention to media coverage about COVID-19. On the one hand, this could be a sign of strong pre-existing concerns about COVID-19. On the other hand, it could indicate less scope for the treatment manipulation to shift participants' emotions because their opinions about the pandemic are less malleable.

[20] I also compute Spearman's rank correlation coefficients, presented in Table A.5. With respect to the relationship between changes in productivity and changes in emotions, the estimated correlations support the conclusions of the regression analysis. An additional insight of the correlation matrix is that changes in worry are negatively correlated with changes in happiness with a correlation coefficient of -0.165 ($p = 0.007$), suggesting that subjects' negative emotional response to the treatment manipulation in these two dimensions is closely linked.

Table 3. Changes in Worry and Happiness and Changes in Labor Productivity

	Dependent variable: Change in productivity		
	(1)	(2)	(3)
Change in worry	0.050		0.062
	(0.105)		(0.107)
Change in happiness		0.025	0.034
		(0.072)	(0.074)
Constant	1.082***	1.109***	1.092***
	(0.153)	(0.153)	(0.157)
Observations	268	268	268
R^2 (adjusted)	−0.003	−0.003	−0.006
Mean (dependent variable)	1.099	1.099	1.099

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. *Change in productivity* is the difference in the average number of correct answers per block between non-news blocks and baseline. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

Both candidate characteristics are related to baseline differences in emotional state. Subjects with higher PSWQ scores are more worried and less happy at baseline, with differences in means of 0.809 ($p = 0.005$, two-sided test with robust standard errors) and 1.433 ($p < 0.001$) scale points between subjects with above-median and below-median scores, respectively. Subjects who report following the news about COVID-19 are more worried, but equally happy, at baseline compared to their less interested peers. Here, the difference in the mean level of worry across the two groups is 0.759 scale points ($p = 0.022$).

To investigate whether these baseline differences in emotional state translate into differential treatment effects, I conduct heterogeneity analyses. Figure 3 plots separate estimates of the main treatment effect for different partitions of the analysis sample along the two specified characteristics.[21]

Qualitatively, the point estimates suggest stronger treatment effects for subjects with lower PSWQ scores, as if those with a greater general tendency to worry were more adept at warding off worry-induced distractions, and for subjects who follow the news about COVID-19. However, the estimates are always above the lower confidence limit of the full sample treatment effect and never significantly different from zero. Thus, there is no evidence that worrying about COVID-19 impairs productivity even among assumably more susceptible subpopulations.[22]

Taking stock, I find no evidence that the main treatment manipulation reduces labor productivity across a variety of conducted analyses even though it induces a strong negative emotional response. In a final analysis regarding Hypothesis 2, I test whether unintended side effects of the intervention which are unrelated to worrying about COVID-19 could mask an effect of worrying on productivity. A prime candidate is that the worry-evoking video motivates subjects to work harder by shifting their

[21] I also show results from a tercile split by PSWQ score to alleviate concerns that heterogeneous effects might be non-monotonic.

[22] I also check for heterogeneous emotional responses to the treatment manipulation. The respective estimates, plotted in Figure A.4 in the appendix, show no clear patterns of stronger emotional responses for more susceptible subgroups of the sample. The treatment manipulation induces significant shifts in both worry and happiness in all subsamples. Subjects with a lower PSWQ score seem to show relatively weaker emotional responses, but only the differential treatment effect in happiness of 0.952 scale points relative to the medium-PSWQ-score subsample is significant at the ten percent level ($p = 0.057$ in an F-test).

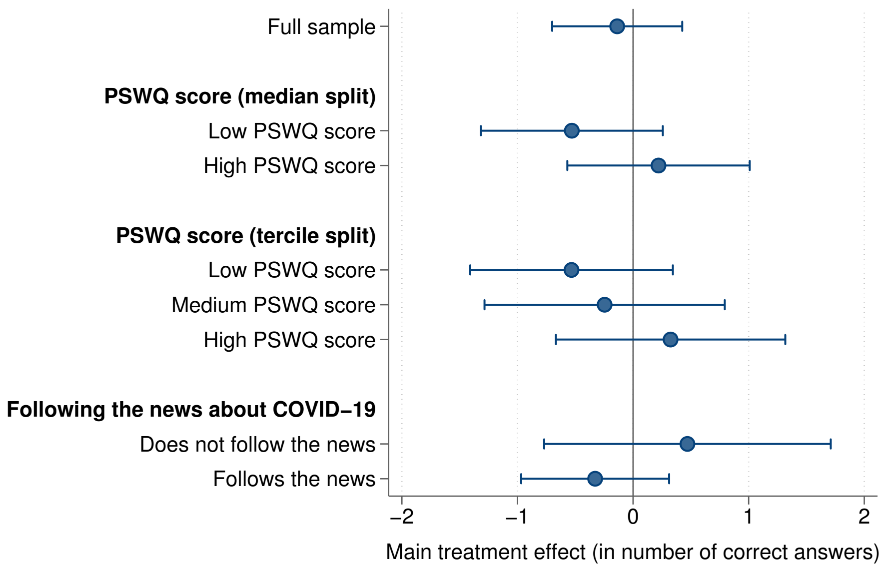

Figure 3. Heterogeneity in the Main Treatment Effect on Labor Productivity

Notes: Plot of coefficient estimates of the main treatment effect on labor productivity for the full sample and three different partitions of the full sample into subsamples: a median split by PSWQ score, a tercile split by PSWQ score, and a split by whether or not subjects report following the news about COVID-19. The estimates are from regressions of the subject-level number of correct answers in non-news blocks on indicators for each of that partition's subsamples and their interactions with an indicator for the *Worry-Amplifying* condition, controlling for the number of correct answers and the level of worry at baseline. Error bars indicate 95 percent confidence intervals, constructed using heteroscedasticity-robust standard errors.

beliefs about the financial consequences of the pandemic. In particular, learning about the severity of long-term health effects could induce pessimism about the duration of containment measures, whereas faster vaccination campaigns signal a faster economic recovery. Thus, the two media reports might shift subjects' beliefs about their own future economic prospects in opposite directions, ultimately resulting in a greater perceived marginal value of each Euro earned in the experiment for subjects exposed to the worry-inducing video. As a consequence, subjects in the *Worry-Amplifying* condition might work harder for reasons unrelated to their negative emotional response, thereby counterbalancing an adverse effect of worrying on productivity. Kaur, Mullainathan, et al. (2021) find evidence of such an offsetting motivational effect of a priming intervention designed to increase financial worries in a field experiment with Indian workers under financial strain.

My collected data allows me to assess the plausibility of this concern. Table 4 contains estimates from regressions on an indicator for the *Worry-Amplifying* condition that use subjects' reported level of worry about the consequences of the pandemic on their personal financial situation or their job prospects as the dependent variable. Moreover, I also test whether the main treatment manipulation affects the goal number of correct answers per mental arithmetic block that subjects state just after watching their condition's video clip. None of the reported specifications provides any indication that the main treatment manipulation shifts subjects' beliefs about their financial prospects or motivates them to set higher goals for themselves. The estimated treatment effects for participants' financial concerns are substantially smaller than the respective estimates for health-related worry and happiness in Table 1, and those for their productivity goals have the wrong sign. Moreover, none of the estimates is significantly different from zero.

Table 4. Effect of the Main Treatment Manipulation on Selected Outcomes

Dependent variable:	Worry about financial situation		Worry about job prospects		Goal for correct answers per block	
	(1)	(2)	(3)	(4)	(5)	(6)
Worry-Amplifying condition	−0.008	0.166	−0.093	0.083	−0.280	−0.340
	(0.330)	(0.325)	(0.356)	(0.352)	(0.575)	(0.451)
Worry at baseline (cent.)		0.261***		0.264***		0.133
		(0.071)		(0.077)		(0.135)
Correct answers at baseline (cent.)						0.860***
						(0.062)
Constant	3.538***	3.686***	3.917***	4.066***	11.530***	10.856***
	(0.245)	(0.244)	(0.248)	(0.250)	(0.366)	(0.233)
Observations	268	268	268	268	268	268
R^2 (adjusted)	−0.004	0.045	−0.003	0.038	−0.003	0.511
Mean (dependent variable)	3.534	3.534	3.869	3.869	11.388	11.388

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. *Worry-Amplifying condition* is an indicator equal to one for subjects in the experimental condition of the same name. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

Since the lack of a treatment effect is not explained by countervailing side effects of the treatment manipulation, the natural conclusion is that emotional responses to the COVID-19 pandemic do not impair labor productivity in my experiment. The intuition behind Hypothesis 2 suggests two potential explanations for this null result. First, worrying might not impede cognitive ability in my setting. Eight months into the pandemic, subjects in my sample might have already adapted to the situation and the accompanying negative emotions, such that emotional responses provoked by media reports are not extreme enough to induce a capture of cognitive resources. Second, worry might impede cognitive ability, but subjects compensate for worry-induced cognitive effects by increasing their mental effort.[23] This would be in line with the notion of income targeting: subjects might have a goal number of correct answers in mind that acts as their reference point, and they react to unexpected decreases in perceived productivity by increasing their mental effort to avoid falling short of their goal (e.g., Allen et al., 2017; Duong, Chu, and Yao, Forthcoming). This behavior might even be promoted by the subtle experimental design feature of asking subjects for their goal number of tasks before the second session's working period.

4.4 News Salience and Labor Productivity

Finally, I turn to Hypothesis 3, which predicts that the effect of worry on labor productivity is compounded by a continued salience of the pandemic because this keeps worry top-of-mind. In light of the previous finding that worrying does not affect productivity in the first place, there is no conceptual

[23]There is a subtle difference between this potential explanation for the observed null result and the possibility that an adverse effect of worrying is masked by an offsetting motivational side effect of the treatment manipulation, as explored in Table 4. In particular, only the latter would predict a reduction in labor productivity in situations that arouse worry about COVID-19 without shifting beliefs about financial prospects.

reason to believe that keeping it top-of-mind should matter. For the sake of completeness, I nonetheless report the corresponding estimates in Table A.6 and Table A.7 in the appendix.

To test the hypothesis, I analyze labor productivity in news blocks, during which news headlines are displayed to subjects in between mental arithmetic problems. The headlines are either about the COVID-19 pandemic or neutral topics, depending on the cross-randomized secondary experimental condition. I report estimates of the effect of the *COVID-19 Headlines* subcondition for each of the two subsamples that arise from the main treatment manipulation as well as the interaction between indicators for conditions *COVID-19 Headlines* and *Worry-Amplifying* for the full sample. The interacted model additionally accounts for productivity effects of the displayed news headlines that are unrelated to worrying about COVID-19. For instance, the neutral headlines could be more interesting and thus more distracting than the pandemic-related headlines even if worrying plays no role. All models are estimated once with and once without additionally controlling for worry at baseline.

In line with expectations given the previous results, the estimated coefficients of interest are close to zero and statistically insignificant in all models.

4.5 Evidence for Worry-Induced Attentional Capture

The intuition behind the hypothesized effect of worrying on labor productivity is that scarce cognitive resources are redirected towards the object of concern, thus reducing their availability for other tasks (e.g., Eysenck et al., 2007; Mullainathan and Shafir, 2013; Lichand and Mani, 2020). Therefore, one potential explanation for the observed lack of a treatment effect in my setting is that the emotional responses provoked by the news video clips in my experiment simply do not affect subjects' cognitive processes. To get a first indication of the empirical plausibility of this explanation, I look for direct evidence of changes in cognition in response to the main treatment manipulation.

Remember that participants are exposed to headlines from current news articles in between mental arithmetic problems during the two news blocks of the second session. Depending on their secondary experimental condition, the displayed headlines are either about a neutral topic or related to the COVID-19 pandemic. To proxy for attentional capture, I use participants' interest in the news headlines that they are exposed to, as measured by whether they click on a button to save them for later reading. In particular, I examine whether the relative propensity to save news articles about COVID-19 differs between the *Worry-Amplifying* and *Worry-Alleviating* condition.

Corresponding regression estimates are reported in columns (1) and (2) of Table 5. I account for differences in the number of headlines subjects see by adding the attempted number of arithmetic problems at baseline as an additional covariate. The small and insignificant point estimate on the coefficient for the *COVID-19 Headlines* subcondition indicates that the article topic barely affects the number of saved articles in the *Worry-Alleviating* condition. In comparison, the worry-inducing video clip reduces the number of neutral articles bookmarked by statistically significant 1.07 articles, which is a 50 percent reduction relative to the average number of saved neutral articles in the *Worry-Alleviating* condition of 2.30.[24] At the same time, the worry-inducing video clip does not meaningfully reduce the number of

[24] I did not specify a hypothesis for this coefficient in the pre-analysis plan because the the main treatment manipulation could also have a topic-independent effect on the number of saved articles, e.g., by reducing the number of mental arithmetic

pandemic-related articles that subjects save, as implied by a slightly smaller interaction effect of opposite sign. This interaction effect, however, is not statistically significant.

Table 5. Effect of the Main Treatment Manipulation on News Interest

Dependent variable:	Number of saved articles		At least one saved article	
	(1)	(2)	(3)	(4)
Worry-Amplifying condition	−1.115**	−1.070**	−0.295***	−0.286***
	(0.469)	(0.482)	(0.083)	(0.084)
COVID-19 Headlines subcondition	−0.101	−0.100	−0.086	−0.085
	(0.529)	(0.531)	(0.088)	(0.088)
Worry-Amplifying condition × *COVID-19 Headlines* subcondition	0.931	0.933	0.324***	0.324***
	(0.700)	(0.701)	(0.122)	(0.122)
Attempted answers at baseline (cent.)	0.002	0.010	−0.006	−0.004
	(0.043)	(0.043)	(0.009)	(0.009)
Worry at baseline (cent.)		0.073		0.015
		(0.076)		(0.013)
Constant	2.255***	2.297***	0.594***	0.603***
	(0.378)	(0.379)	(0.061)	(0.063)
Observations	268	268	268	268
R^2 (adjusted)	0.010	0.010	0.041	0.043
Mean (dependent variable)	1.866	1.866	0.481	0.481

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. The dependent variables are measures of subjects' interest in task-irrelevant news articles whose headlines are displayed to them in between mental arithmetic problems during news blocks: the total number of articles saved for later reading in columns (1) and (2) and an indicator for saving at least one article in columns (3) and (4). *Worry-Amplifying condition* and *COVID-19 Headlines subcondition* are indicators equal to one for subjects in the experimental conditions of the respective name. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

As revealed by the small value of the constant, the general propensity of experimental participants to save articles is low. As a consequence, few subjects who save many articles could have a large impact on the estimates in columns (1) and (2). To assess whether the conclusions are robust, I also use an indicator for saving at least one article as an alternative outcome measure. The resulting estimates in columns (3) and (4) are qualitatively in line with those for the count outcome and exhibit similarly meaningful effect sizes. In these specifications, the interaction effect is significantly different from zero as well.

Since the effect of the worry-inducing video on news interest depends on the article topic, it cannot be explained by a general effect of worrying on the ability to withstand distractions. Similarly, differences in the demand for information about COVID-19 induced by the main treatment manipulation cannot explain the observed lower interest in neutral news articles because these articles do not have any connection to the video clips. Therefore, the estimates suggest that exposure to the worry-inducing

problems subjects attempt. However, in the absence of a treatment effect on the number of attempted problems—which I verify in unreported regressions—, the large negative coefficient already provides a first indication that worrying reduces attention to pandemic-unrelated aspects of information.

video indeed increases subjects' relative focus on pandemic-related news, in line with attentional capture. In particular, they document a substantial decrease in demand for news about topics unrelated to COVID-19. With respect to the interpretation of the null result for Hypothesis 2, this piece of evidence is of course only suggestive because I cannot assess whether the relative shift in subjects' attention towards pandemic-related news really translates into reduced focus on the cognitive task.

The estimated effects of the main treatment manipulation on news interest are also interesting in their own right. In text analyses of the media coverage of the COVID-19 pandemic in the US, Sacerdote, Sehgal, and Cook (2020) document that articles by major US news outlets are overwhelmingly negative in tone and the choice of covered topics, irrespective of real-world epidemiological developments. My estimates offer a potential explanation for this observation. They indicate that for media outlets which compete for the attention of worried readers, producing pessimistic articles about the pandemic might be an optimal strategy.[25]

4.6 Effect of the Main Treatment Manipulation on Self-Perceived Productivity

In Section 4.3 and Section 4.5, I show that worrying does not reduce labor productivity in the context of my experiment even though it shifts relative attention to news articles about COVID-19. In this subsection, I present suggestive evidence on one potential explanation for these findings: since solving mental arithmetic problems also has an effort component, subjects might be able to compensate for worry-induced reductions in task-available cognitive function by putting in more mental effort.[26]

One implication of an increase in required mental concentration is that the cognitive task should feel more difficult for subjects who are exposed to the worry-inducing treatment manipulation. Table 6 contains estimates of the effect of the main treatment manipulation on three different survey outcomes that are related to subjects' perceptions of their performance on the cognitive task.

In columns (1) and (2), the outcome is a summary measure of subjects' self-assessed productivity in non-news blocks and news blocks relative to the baseline session.[27] The dependent variable is coded as −1, 0, and 1 if subjects guess that they answered more, approximately the same, or fewer problems correctly in the second session, respectively.[28] The estimated coefficients indicate that perceived productivity is marginally significantly lower in the *Worry-Amplifying* condition for non-news blocks, while the estimated treatment effect is close to zero for news blocks.

In column (3), I compare subjects' reported level of satisfaction with their task performance in the second session across conditions. Taken at face value, the negative treatment effect estimate of one quarter of a scale point suggests that subjects who are exposed to the worry-inducing video clip are

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[25] Since my experimental design only varies the topic of displayed headlines, I cannot say whether positively framed headlines about COVID-19 would have generated similar increases in relative news interest. However, the selected pandemic-related headlines are arguably more pessimistic on average than those displayed in the *Neutral Headlines* subcondition.

[26] The analyses in this subsection are not preregistered.

[27] To keep the question simple, subjects are asked to consider their productivity relative to their performance in the whole first session rather than only in the second block of the first session, which is used as the baseline measure of task performance throughout the paper. As a result, the definition of the term "baseline session" used in this subsection differs from the definition of baseline productivity used in other analyses.

[28] Distributions of the individual responses by experimental condition are plotted in Figure A.5. In general, participants have some insight into their productivity. The Spearman correlation coefficients between my measure of perceived productivity and the actual change in the number of correct answers relative to the first session is 0.386 ($p < 0.001$) for non-news blocks and 0.333 ($p < 0.001$) for news blocks.

Table 6. Effect of the Main Treatment Manipulation on Measures of Self-Perceived Productivity

Dependent variable:	Perceived productivity in non-news blocks	Perceived productivity in news blocks	Satisfaction with own performance	Concentration on the task impaired by video	
	(1)	(2)	(3)	(4)	(5)
Worry-Amplifying condition	−0.172*	0.023	−0.265	0.128***	0.157***
	(0.095)	(0.102)	(0.265)	(0.041)	(0.049)
Worry at baseline (cent.)	−0.018	−0.015	−0.042	0.029***	0.011
	(0.020)	(0.022)	(0.061)	(0.008)	(0.011)
Worry-Amplifying condition × Worry at baseline (cent.)					0.033**
					(0.017)
Constant	0.187***	−0.138*	6.794***	0.085***	0.074***
	(0.066)	(0.074)	(0.191)	(0.024)	(0.025)
Observations	268	268	268	268	268
R^2 (adjusted)	0.007	−0.005	−0.002	0.063	0.074
Mean (dependent variable)	0.116	−0.112	6.698	0.123	0.123

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. Perceived productivity is coded as −1, 0, and 1 if subjects guess that they answered more, approximately the same, or fewer mental arithmetic problems correctly on average in the named second-session blocks relative to the baseline-session blocks, respectively. *Concentration on the task impaired by video* is an indicator equal to one for subjects who report being distracted by thoughts about the content of their condition's video. *Worry-Amplifying condition* is an indicator equal to one for subjects in the experimental condition of the same name. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

slightly less satisfied with their performance on average, but the coefficient is not significantly different from zero.

Finally, I also ask subjects directly whether their concentration on the mental arithmetic problems was impaired by thoughts about the content of the video they had seen.[29] The coefficient estimates on subjects' answers to this question are reported in column (4). At the median value of baseline worry, the worry-inducing video clip increases the propensity to report being distracted by the content of the video by statistically significant 12.8 percentage points, which is an increase of 150 percent relative to the average of the *Worry-Alleviating* condition. Interestingly, the propensity to feel distracted by thoughts about the content of the video also increases in subjects' baseline level of worry about COVID-19, consistent with the notion that worrying makes it harder to concentrate on the cognitive task. This interpretation is further corroborated in column (5), which includes the interaction term between the treatment dummy and baseline worry. The likelihood of self-reported reductions in focus on the task caused by the worry-inducing video clip increases by about 3.3 percentage points for each scale point of baseline worry.

Taken together, the estimates point towards a decrease in subjects' perceived productivity caused by the worry-inducing video clip, in line with the idea that subjects feel less productive because they have to exert more effort to accomplish the cognitive task. However, the differences between the two

[29] Since this is a blunt question, it might be susceptible to experimenter demand effects (e.g., Zizzo, 2010). However, note that it is not obvious why experimenter demand should be stronger in the *Worry-Amplifying* condition. If subjects mistakenly believed that the main purpose of the experiment was to compare their task outcomes between the first and second session and wanted to please the experimenter to the same extent in both conditions, the estimated between-subjects treatment effect would be unaffected.

conditions are only statistically significant at the five percent level for one of the four outcomes and thus far from conclusive.

5 Discussion

The preceding section documents that an exogenous multi-faceted negative emotional response to COVID-19, comprising an increase in worrying and a reduction in happiness, does not reduce labor productivity on a mental arithmetic task in a student sample. Being exposed to news headlines about the pandemic while working also does not have an effect on labor productivity. At the same time, there is suggestive evidence that worrying leads to a shift of attention towards pandemic-related news and makes subjects report a reduced level of focus on the task.

In this section, I discuss unaddressed concerns to the internal validity of these results and try to reconcile my findings with previous research.

5.1 Are the Results Affected by Cheating on the Cognitive Task?

While unavoidable during a pandemic, online experiments come with the disadvantage that they afford the experimenter less control about the behavior of participants during the experiment. In the current study, this raises a potential concern regarding the internal validity of my findings: subjects might cheat on the mental arithmetic problems, and cheating might crowd out treatment effects on productivity. My experimental design prevents the most obvious form of cheating—using a standard calculator—by keeping subjects' hands busy. However, inhibiting cheating completely on an online task that requires cognitive abilities is difficult. For instance, I cannot rule out that subjects circumvent my measures by getting help from a second household member or using a voice-controlled calculator. This possibility is also mentioned by one subject in the questionnaire. However, there are several patterns in the data that are inconsistent with widespread cheating.

First, there is a sizable number of incorrect answers. On average, subjects answer 13.5 percent of their attempted mental arithmetic problems incorrectly in the second session, and only 7 out of 268 subjects do not make a single mistake. If a majority of subjects used a voice-controlled calculator, I would expect fewer errors.

Second, there is evidence for a trade-off between improvements in calculation time and error rate. Naturally, subjects' performance on the task improves on average between the first and the second session as they gain practice. These improvements can be driven by decreases in the error rate or by decreases in calculation time, i.e., the number of seconds subjects spend thinking on each problem. However, one would normally expect large improvements in one dimension to come at the expense of the other dimension, reflecting the inherent trade-off between speed and quality. In contrast, subjects who come up with a way to cheat can probably achieve large improvements in both dimensions simultaneously. In support of rule compliance, the Pearson's correlation coefficient between the percentage change in success rate and the percentage change in average calculation time from baseline to the second session is 0.278 ($p < 0.001$).[30]

Third, subjects performance on individual problems varies with problem difficulty. Two of the first ten mental arithmetic problems in each block were deliberately selected to be easier than the others. Easy problems are characterized by fewer carries and borrows from the unit digit to the tens or hundreds digit or by a subtrahend that cancels out with one of the summands, thus reducing the number of mental operations required to arrive at the solution. An example is the problem $21 + 71 - 21 + 14$. For participants who cheat by using a voice-controlled calculator, the distinction between easy and hard problems is inconsequential because it does not meaningfully affect the speed of the calculator, but subjects who solve the problems by means of mental arithmetic should do better on easy problems. To test this, I compute the subject-level average calculation time and success rate in the second session separately for easy and more difficult problems. On average, subjects have a 29.8 percent lower average calculation time and a 7.3 percent higher success rate on easy problems (both significantly different from zero with $p < 0.001$ in a two-sided test). 171 subjects do strictly better on easy tasks in both dimensions, compared to only 11 subjects who do not improve in at least one.

To further alleviate concerns that cheating could affect my conclusions, I conduct a robustness check that excludes potential cheaters. In particular, I drop subjects who either improve by more than 20 percent in both calculation time and success rate from baseline to the second session or who do not do better on easy tasks in at least one dimension. These criteria also capture the one subject who brings up the possibility of using a voice-controlled calculator in the questionnaire. The estimated coefficients for the three main hypotheses, presented in Table C.2 in Appendix C, are very similar to those for the full sample.

Taken together, even though isolated cases of subject misbehavior are likely, there is evidence that the majority of participants adheres to the rules of the experiment, and the estimates are robust to the exclusion of suspected cheaters. Therefore, it seems unlikely that my conclusions are affected by the possibility of cheating on the cognitive task.

5.2 Differences to Findings from Previous Research

My findings relate to work in economics on the role of emotions as determinants of cognitive function and labor productivity. Further discussion seems merited with respect to two distinct lines of research: studies on the cognitive effects of worrying that originate from work on the psychological consequences of poverty, and studies on the effect of happiness on productivity from labor economics.

Cognitive effects of worrying. The idea that worrying may impede cognitive function in general and labor productivity in particular is the focus of an emerging line of research in behavioral development economics on the psychology of poverty. It hypothesizes that poverty itself can impair decision-making and worker productivity among the poor because the perception of scarcity captures cognitive resources, thereby creating a vicious cycle of poverty (Shah, Mullainathan, and Shafir, 2012; Mullainathan and

[30] I use the success rate rather than the error rate here to avoid problems with division by zero for subjects without any errors at baseline.

Shafir, 2013). Empirical evidence on the effect of financial strain on cognitive function has been mixed. While results from early priming experiments and analyses of natural variation in income before and after payday are generally supportive of the theory (e.g., Mani et al., 2013), they do not always replicate in more recent investigations in similar settings (e.g., Carvalho, Meier, and Wang, 2016). In an attempt to reconcile the existing evidence, Lichand and Mani (2020) show that income uncertainty rather than a low income level is associated with reduced cognitive test scores for farmers in Brazil, consistent with the interpretation that worry is an important driver of the effect.[31] Kaur, Mullainathan, et al. (2021) demonstrate that financial constraints can also impair worker productivity in a recent field experiment which varies whether workers are paid at the end of the working period or receive parts of their earnings upfront. The findings of Apenbrink (2021) on the adverse effect of Ebola concern on cognitive function in the US can be seen as an extension of this literature from worrying about income to worrying about health.

One potential explanation for the discrepancies between my findings here and those in Apenbrink (2021) is that exposure to different media reports about a given level of epidemic activity—i.e., a pure manipulation of perception—induces a weaker emotional response than the variation in actual epidemic activity exploited in the analysis of the cognitive cost of US Ebola cases. Specifically, the shift in worry caused by the current treatment manipulation might not be extreme enough to meaningfully affect subjects' cognitive function.[32] Presumably, the difference in the strength of emotional responses is magnified by (i) the subjectively more horrific nature and case fatality rate of Ebola compared to COVID-19, (ii) the difference in sample composition between young university students and old people from all social classes, and (iii) the later timing of the current experiment in the life cycle of the epidemic, when many people have probably adapted to the threat and the general level of uncertainty is low. In contrast, the analysis in Apenbrink (2021) explores a situation of high uncertainty just at the onset of a potential epidemic. From this perspective, the current study tests the limits of a meaningful effect of epidemic-induced worry on cognitive function.

An alternative interpretation is suggested by my findings regarding subjects' selective attention to pandemic-related news in Section 4.5 and their self-perceived productivity in Section 4.6. These pieces of evidence indicate that the emotional response evoked in the context of the current experiment affects cognition, but the cognitive effects do not translate into meaningful differences in labor productivity. In contrast to pure tests of cognitive ability, solving mental arithmetic problems also requires a substantial degree of effort. Therefore, participants in the current study might be able to compensate for worry-induced reductions in task-available cognitive resources by putting in more mental effort, maybe with the intention of reaching an earnings goal that serves as their reference point.

Happiness and labor productivity. My study also connects to a large body of research on the relationship between employee well-being and employee productivity (reviewed, e.g., in Krekel, Ward, and De Neve,

[31] See de Bruijn and Antonides (2022) for a detailed review of the relevant studies and a discussion of the general state of the evidence.

[32] Kaur, Mullainathan, et al. (2021) make a similar point about the difference between priming and alleviating financial strain in experimental tests of the causal effects of scarcity. This would also be consistent with the results of Bogliacino, Codagnone, Montealegre, Folkvord, Gómez, et al. (2021), who document negative associations between various self-reported adverse real-life shocks during the COVID-19 pandemic and cognitive function outcomes, but do not find an effect with an experimental priming intervention.

2019). Much of this literature is correlational or unsuitable to pin down a direct effect of positive affect on productivity, but the findings from causal studies generally suggest a task-specific effect. Whereas Bellet, De Neve, and Ward (2020) find a negative effect of weather-induced reductions in happiness at work on the productivity of call center salespersons, who rely a lot on socioemotional skills, Borowiecki (2017) documents an increase in creative output for composers after unexpected family bereavements.

The one study that is similar enough to warrant closer comparison is Oswald, Proto, and Sgroi (2015), who investigate the causal effect of happiness on labor productivity in a series of laboratory experiments. Though the thematic focus is different, the design of my experiment shares many features with their setup. Both studies employ student samples from European universities, measure productivity on a mental arithmetic task under piece-rate incentives, and induce similarly strong exogenous changes in happiness.[33] In addition, two of the four experiments reported in Oswald, Proto, and Sgroi (2015) also use videos to manipulate emotions.[34] However, while they document an increase in productivity of about 12 percent, the coefficient estimates in my main specification are smaller in absolute value by a factor of ten. The lower bound of the 95 percent confidence interval of my estimate is at approximately -5.8 percent, implying that I can comfortably rule out a change in productivity that is half the size of that found by Oswald, Proto, and Sgroi (2015).

I see two starting points for further research to investigate the reasons for this discrepancy. First, a subtle difference in the design of my experiment is that I ask subjects for their goal number of correct answers before they start working on the mental arithmetic problems of the second session. This design feature is directly related to one potential explanation for my null result: if participants perceive falling short of their stated goal as a loss, this prospect could motivate them to exert the necessary extra effort to compensate for the cognitive effects of a change in happiness. Put differently, setting a goal might make exerted effort decline less in response to increases in effort costs. The possibility that self-chosen goals can preserve productivity in the face of obstacles is also suggested by Kaur, Kremer, and Mullainathan (2015) and Clark, Gill, Prowse, and Rush (2020) in the context of self-control problems.[35]

Second and relatedly, the productivity consequences of changes in happiness might be asymmetric: happiness decreases might not have the same effect on productivity as comparable increases in happiness. In particular, it seems less likely that individuals will adjust their cognitive effort downwards if a boost to their well-being frees up additional cognitive resources by diverting their attention from pre-existing concerns. While Oswald, Proto, and Sgroi (2015)—in their fourth experiment—report a significant association between participants' productivity in the laboratory and natural variation in happiness after the experience of family tragedies that would cast doubt on this conjecture, they also acknowledge that this particular piece of evidence is not as convincing as their other experiments. For instance, it could also be explained by a correlation between productivity and latent health risks or life circumstances which increase the likelihood of experiencing illness or death.

[33] Oswald, Proto, and Sgroi (2015) report a posttreatment level difference in happiness of 0.67 points on a 7-point scale in their second experiment, which also uses video clips as the source of exogenous variation. By comparison, my treatment manipulation induces a happiness difference of 1.45 points on an 11-point scale. Both estimates correspond to an effect size of about 0.7 SD.

[34] In the other two experiments, they provide a random subset of participants with snacks and drinks at the beginning of the session or analyze the effect of natural variation in the experience of a major real-world shock like the recent death of a close family member.

[35] Economic experiments also provide evidence that personal goals increase productivity more generally (e.g., Goerg and Kube, 2012).

6 Conclusion

By means of an online experiment, I show that negative emotional responses to the COVID-19 pandemic induced by media reports do not have a meaningful negative effect on labor productivity in a cognitively demanding task in a sample of university students eight months into the pandemic. This null result is robust across a variety of analyses and cannot be explained by unintended countervailing motivational effects of the treatment manipulation or cheating on the task. Yet, I provide suggestive evidence that worrying leads to a selective shift of attention towards pandemic-related news and an increase in the occurrence of distracting thoughts that make it harder for subjects to keep concentrated while working, in line with the intuition that negative emotions have adverse cognitive effects. One plausible interpretation of these findings is that subjects make up for worry-induced distractions by putting in more cognitive effort, consistent with the notion of income targeting.

My findings have implications for optimal public communication during epidemics: they indicate that exposure to information about the danger of the disease does not have a direct adverse effect on labor productivity. This is good news for policymakers who want to promote adherence to COVID-19 preventive measures by reiterating the threat of the virus in public communication. However, my findings also imply that this can come at the cost of short-term reductions in happiness above and beyond foregone utility from induced changes in behavior.

If one feels comfortable to extrapolate from my results to a comparison with the counterfactual situation without COVID-19, my findings also suggest that labor productivity declines of otherwise unaffected workers as a result of negative emotional responses are not a key channel by which epidemics disrupt the economy, at least not in later stages of the epidemic when people have had time to adapt to the new situation. However, in light of the context of my experiment and the pattern of findings in previous research on the effect of emotions on productivity, it is unclear whether my conclusions readily extend to this comparison, which implies much stronger emotional reactions. Moreover, it is important to keep in mind that epidemic-induced worry can also harm the economy in other ways, e.g., by inducing deliberate behavioral changes of workers and consumers, and that it presumably comes with negative health consequences by itself (e.g., Blix, Birkeland, and Thoresen, 2021). Therefore, it still seems warranted to prevent the spread of excessive fears that may arise from an epidemic.

Future research should seek to clarify the conditions under which emotions affect economic outcomes. Of particular interest could be the role of salient goals, which might be an important factor for maintaining productivity in the face of worry and unhappiness.

Appendix A Additional Figures and Tables

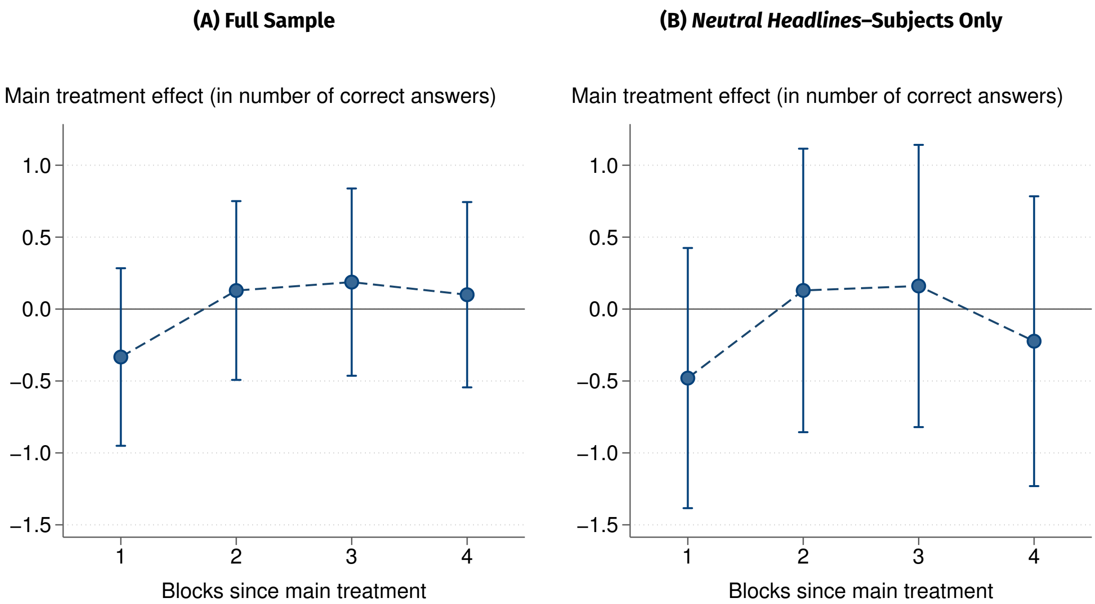


Figure A.1. Evolution of the Main Treatment Effect over Time

Notes: Coefficient estimate plots of block-specific main treatment effects for each second-session block of mental arithmetic problems. Blocks 1 and 2 are non-news blocks, blocks 3 and 4 are news blocks. The estimates are from a regression of the subject-block-level number of correct answers on indicators for each second-session block and their interactions with an indicator for the *Worry-Amplifying* condition, controlling for the number of correct answers at baseline and the baseline level of worry. Error bars indicate 95 percent confidence intervals, constructed using standard errors that are robust to heteroscedasticity and arbitrary intra-cluster correlation within subjects. Panel (A) shows coefficient estimates from the full sample, Panel (B) uses only the subsample of subjects in the *Neutral Headlines* subcondition.

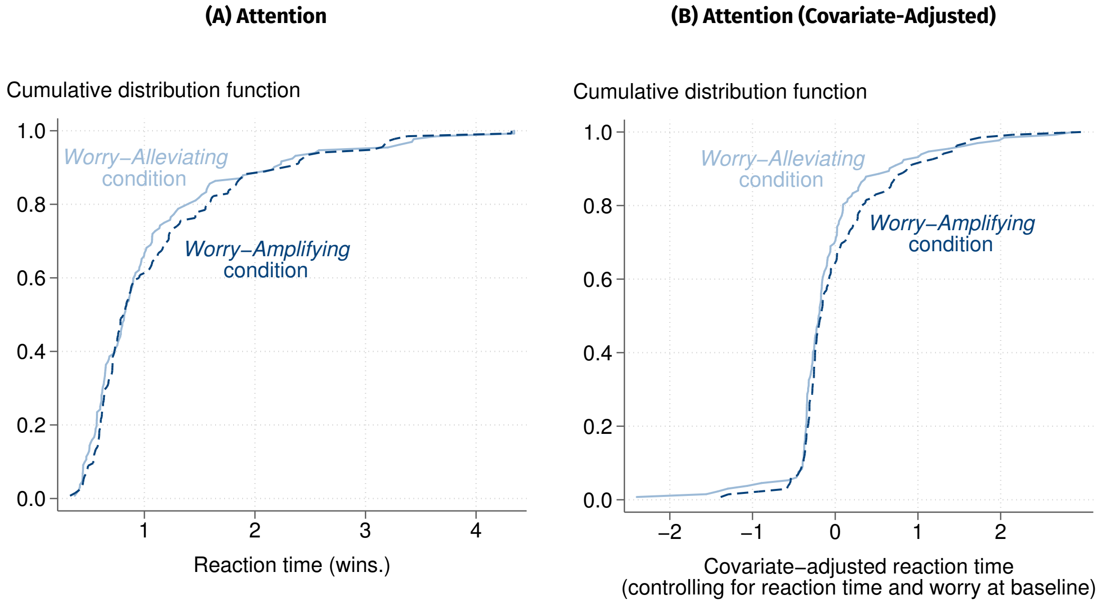
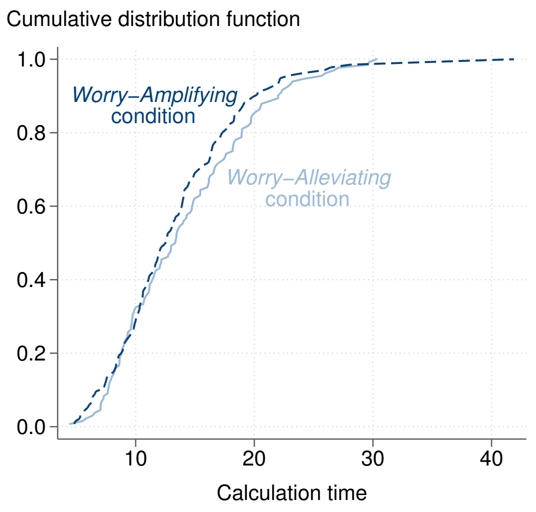


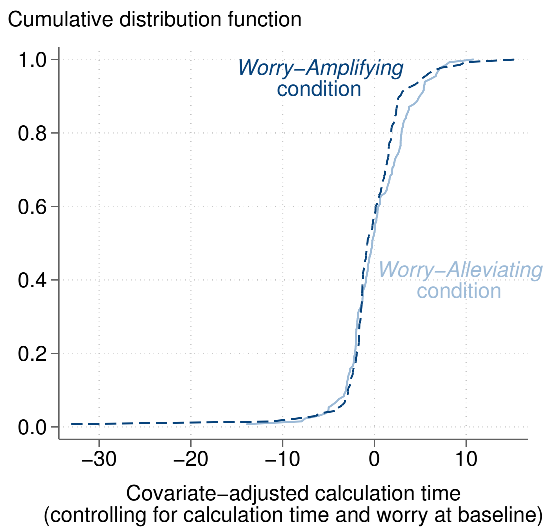
Figure A.2. Attention in Non-news Blocks by Experimental Condition

Notes: The cumulative distribution of a measure of attention in non-news blocks, plotted separately for subjects in the *Worry-Amplifying* condition (dashed dark blue line) and the *Worry-Alleviating* condition (solid light blue line). Panel (A) shows the distribution of average reaction time in seconds across all mental arithmetic problems attempted in the two blocks. Panel (B) shows the distribution of the residuals from a regression of average reaction time on average reaction time at baseline and the baseline level of worry. Both reaction time variables used to calculate the cumulative distribution functions are winsorized by replacing the highest with the second-highest value in each condition.

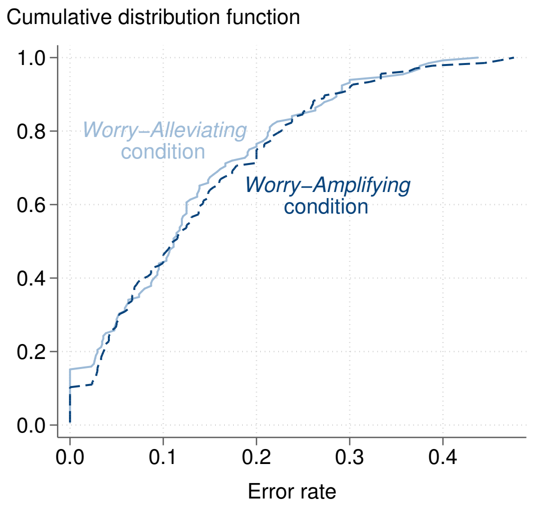
(A) Working Memory (Calculation Time)



(B) Working Memory (Covariate-Adjusted Calculation Time)



(C) Working Memory (Errors)



(D) Working Memory (Covariate-Adjusted Errors)

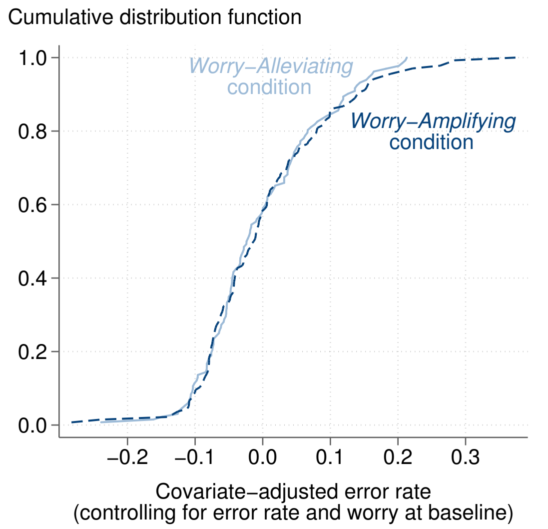


Figure A.3. Working Memory in Non-news Blocks by Experimental Condition

Notes: The cumulative distribution of two measures of working memory in non-news blocks, plotted separately for subjects in the *Worry-Amplifying* condition (dashed dark blue line) and the *Worry-Alleviating* condition (solid light blue line). Panel (A) shows the distribution of average calculation time in seconds across all mental arithmetic problems attempted in the two blocks. Panel (B) shows the distribution of the residuals from a regression of average calculation time on average calculation time at baseline and the baseline level of worry. Panel (C) shows the distribution of the average error rate (i.e., the fraction of incorrect answers) across the two blocks. Panel (D) shows the distribution of the residuals from a regression of the average error rate on the baseline error rate and the baseline level of worry.

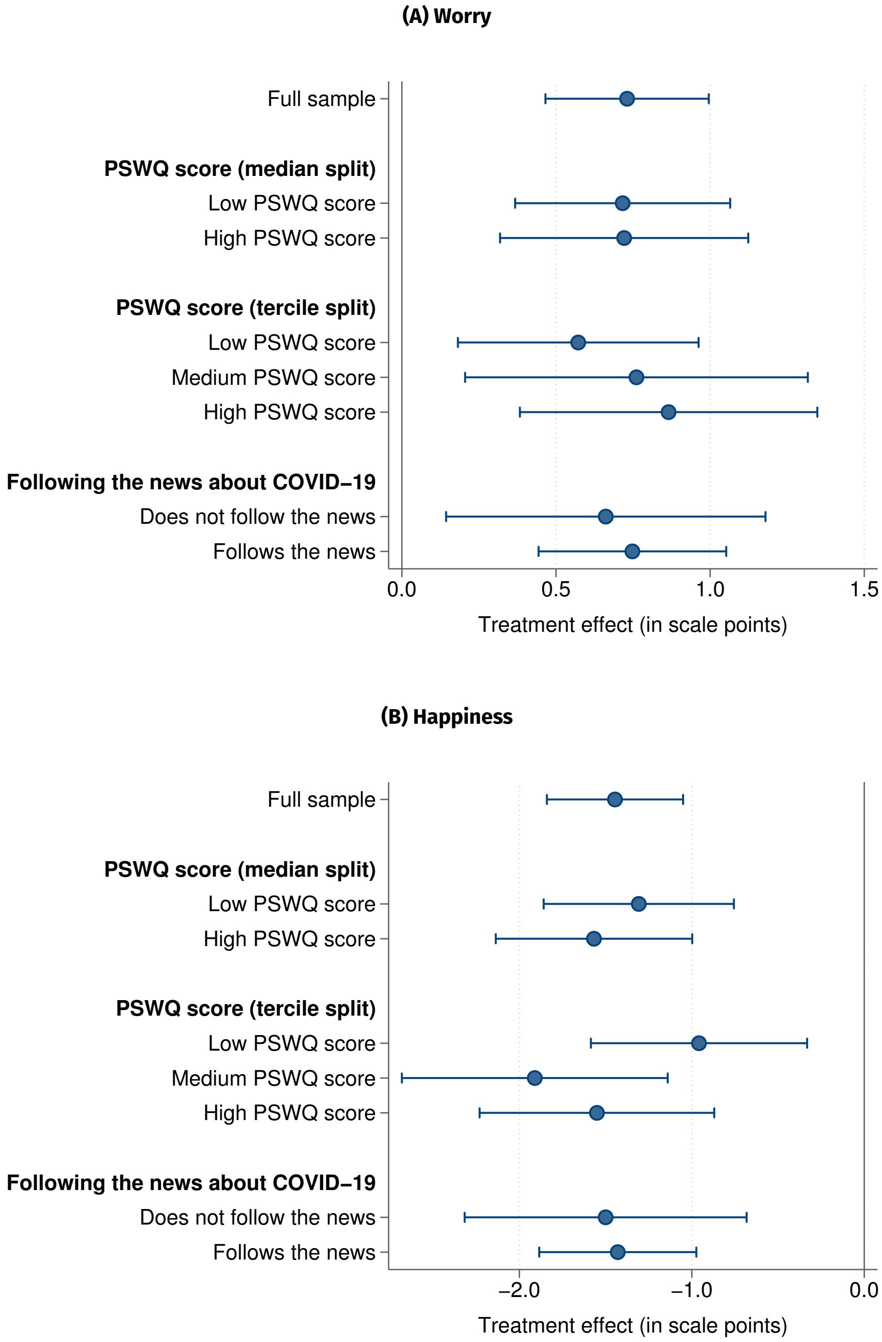
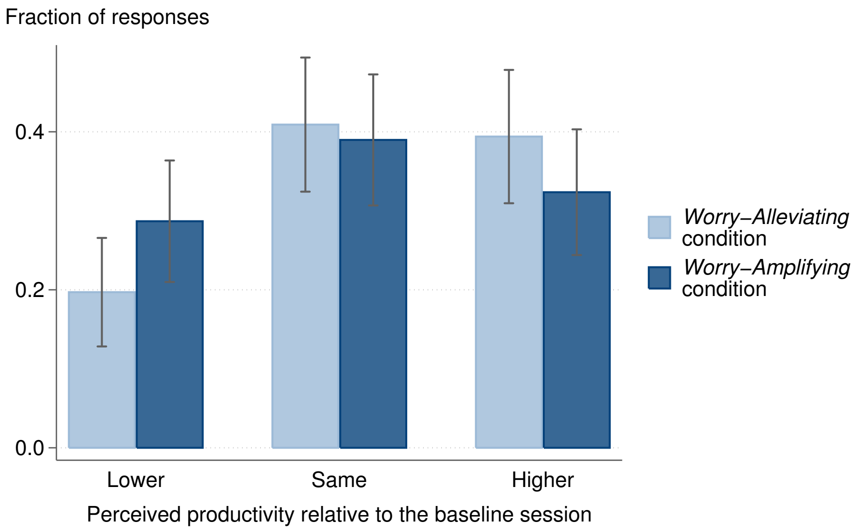


Figure A.4. Heterogeneity in the Effect of the Main Treatment Manipulation on Worry and Happiness

Notes: Plots of coefficient estimates of the effect of the main treatment manipulation on worry and happiness for the full sample and three different partitions of the full sample into subsamples: a median split by PSWQ score, a tercile split by PSWQ score, and a split by whether or not subjects report following the news about COVID-19. The estimates are from regressions of subjects' level of worry or happiness after the main treatment manipulation on indicators for each of that partition's subsamples and their interactions with an indicator for the *Worry-Amplifying* condition, controlling for the level of worry or happiness at baseline. Error bars indicate 95 percent confidence intervals, constructed using heteroscedasticity-robust standard errors. Panel (A) shows coefficient estimates for the treatment effect on worry, Panel (B) for the effect on happiness.

(A) Non-news Blocks



(B) News Blocks

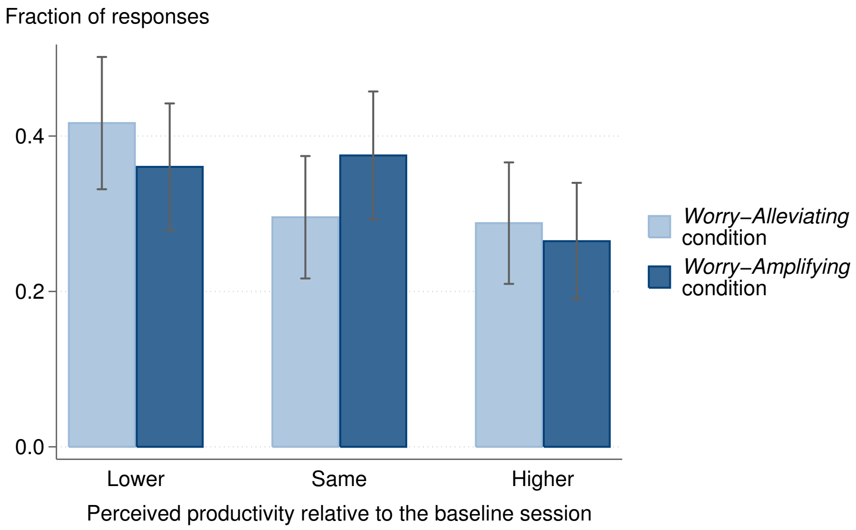


Figure A.5. Perceived Productivity in Non-news Blocks and News Blocks by Experimental Condition

Notes: Bar charts of productivity perceptions for the two types of second-session blocks relative to the baseline session, plotted separately for subjects in the *Worry-Alleviating* condition (in light blue) and the *Worry-Amplifying* condition (in dark blue). Panel (A) shows the distribution of responses for relative productivity in non-news blocks, Panel (B) for relative productivity in news blocks.

Table A.1. Descriptive Statistics for the Analysis Sample

Variable	Mean	SD	Min.	Median	Max.	Obs.
Worry	6.425	2.327	0	7	10	268
Worry at baseline	6.093	2.369	0	7	10	268
Change in worry	0.332	1.235	−3	0	7	268
Happiness	5.817	2.134	0	6	10	268
Happiness at baseline	6.224	1.972	0	7	10	268
Change in happiness	−0.407	1.972	−7	0	8	268
Female	0.604	0.490	0	1	1	268
Age	25.922	7.191	16	24	72	268
Bachelor's degree	0.321	0.468	0	0	1	268
Master's degree	0.190	0.393	0	0	1	268
High school GPA	2.168	0.751	1.150	2.150	5.000	268
No high school GPA	0.022	0.148	0	0	1	268
High school math grade	2.298	0.902	1.150	2.150	5.000	268
No high school math grade	0.007	0.086	0	0	1	268
Correct answers at baseline	10.959	3.952	1	10	21	268
Correct answers per non-news block	12.058	3.889	3.500	11.500	21.500	268
Change in productivity	1.099	2.404	−8.000	1.000	12.000	268
Correct answers per news block	12.326	4.024	3.000	12.250	24.000	268
Reaction time at baseline	1.864	9.639	0.307	0.916	157.706	267
Reaction time at baseline (wins.)	1.293	1.141	0.307	0.916	7.550	267
Reaction time in non-news blocks	1.191	1.629	0.328	0.818	24.357	267
Reaction time in non-news blocks (wins.)	1.110	0.789	0.328	0.818	4.345	267
Calculation time at baseline	15.029	6.792	3.673	13.961	68.660	267
Calculation time in non-news blocks	13.749	5.750	4.464	12.936	41.889	267
Error rate at baseline	0.167	0.159	0.000	0.133	0.800	268
Error rate in non-news blocks	0.132	0.107	0.000	0.111	0.476	268
Attempted answers at baseline	12.959	3.427	1	13	23	268
Goal for correct answers per block	11.388	4.693	2	10	50	268
PSWQ score	48.172	13.090	16	46	80	268
Follows the news about COVID-19	0.761	0.427	0	1	1	268
Video contained new information	0.500	0.501	0	1	1	268
Belief about infection risk	27.560	23.753	0	20	100	268
Belief about risk of long-term effects	11.060	13.185	0	9	85	268
Belief about risk of death	3.575	6.689	0	1	60	268
Belief about months till vaccination	8.220	7.488	1	6	60	268
Does not believe in vaccination	0.004	0.061	0	0	1	268
Worry about financial situation	3.534	2.682	0	3	10	268
Worry about job prospects	3.869	2.902	0	4	10	268
Number of saved articles	1.866	2.828	0	0	15	268
At least one saved article	0.481	0.501	0	0	1	268
Satisfaction with own performance	6.698	2.115	0	7	10	268
Concentration on the task impaired by video	0.123	0.329	0	0	1	268

Notes: Mean, standard deviation, minimum, median, maximum, and number of observations of important variables for the analysis sample.

Table A.2. Descriptive Statistics by Experimental Condition and Test of Balance

Variable	*Worry-Alleviating* condition	*Worry-Amplifying* condition	Difference of means	Standardized difference of means	Test of balance *p*-value
Worry at baseline	6.432	5.765	0.667	0.282	0.023
	(2.245)	(2.447)			
Happiness at baseline	6.189	6.257	−0.068	−0.034	0.967
	(2.112)	(1.834)			
Female	0.629	0.581	0.048	0.098	0.423
	(0.485)	(0.495)			
Age	25.879	25.963	−0.084	−0.012	0.911
	(7.349)	(7.062)			
Bachelor's degree	0.318	0.324	−0.005	−0.011	0.925
	(0.468)	(0.470)			
Master's degree	0.174	0.206	−0.032	−0.080	0.509
	(0.381)	(0.406)			
High school GPA	2.155	2.181	−0.026	−0.035	0.623
	(0.770)	(0.735)			
High school math grade	2.247	2.347	−0.100	−0.111	0.313
	(0.904)	(0.901)			
Correct answers at baseline	10.871	11.044	−0.173	−0.044	0.909
	(3.916)	(4.000)			
Reaction time at baseline	1.353	2.364	−1.011	−0.105	0.796
	(1.353)	(13.495)			
Reaction time at baseline (wins.)	1.349	1.238	0.110	0.097	0.801
	(1.329)	(0.923)			
Calculation time at baseline	15.098	14.962	0.136	0.020	0.460
	(5.703)	(7.731)			
Error rate at baseline	0.165	0.169	−0.004	−0.027	0.520
	(0.165)	(0.152)			
Attempted answers at baseline	12.788	13.125	−0.337	−0.098	0.346
	(3.288)	(3.562)			
PSWQ score	48.455	47.897	0.557	0.043	0.802
	(12.759)	(13.445)			
Follows the news about COVID-19	0.735	0.787	−0.052	−0.122	0.319
	(0.443)	(0.411)			
Observations	132	136			

Notes: Columns (1) and (2) show the mean values for selected (baseline) subject characteristics by experimental condition, with standard deviations in parentheses. Columns (3) and (4) show the simple and standardized difference of means between the two conditions, where the denominator of the standardized difference is the pooled-sample standard deviation. Column (5) shows the *p*-value of a test of balance across conditions, which is a Mann–Whitney *U* test for continuous and non-binary discrete variables and a Pearson's χ^2 test for binary variables.

Table A.3. Effect of the Main Treatment Manipulation on Measures of Attention

Dependent variable:	Reaction time in non-news blocks			Reaction time in non-news blocks (wins.)		
	(1)	(2)	(3)	(4)	(5)	(6)
Worry-Amplifying condition	0.191	0.166	0.200	0.053	0.097	0.102
	(0.199)	(0.207)	(0.214)	(0.097)	(0.079)	(0.081)
Reaction time at baseline (cent.)		0.025	0.024			
		(0.389)	(0.383)			
Reaction time at baseline (wins., cent.)					0.396***	0.393***
					(0.070)	(0.071)
Worry at baseline (cent.)			0.050			0.008
			(0.038)			(0.014)
Constant	1.094***	1.107***	1.135***	1.083***	1.061***	1.066***
	(0.074)	(0.212)	(0.195)	(0.069)	(0.057)	(0.056)
Observations	267	267	267	267	267	267
R^2 (adjusted)	0.000	0.018	0.019	−0.003	0.323	0.321
Mean (dependent variable)	1.191	1.191	1.191	1.110	1.110	1.110

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. The dependent variable is the average reaction time in seconds across all mental arithmetic problems attempted in non-news blocks. *Worry-Amplifying condition* is an indicator equal to one for subjects in the experimental condition of the same name. The abbreviation "wins." indicates replacement of the highest by the second-highest value of the variable in each condition. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

Table A.4. Effect of the Main Treatment Manipulation on Measures of Working Memory

Dependent variable:	Calculation time in non-news blocks			Error rate in non-news blocks		
	(1)	(2)	(3)	(4)	(5)	(6)
Worry-Amplifying condition	−0.691	−0.606	−0.502	0.006	0.004	0.006
	(0.706)	(0.542)	(0.535)	(0.013)	(0.012)	(0.012)
Calculation time at baseline (cent.)		0.619***	0.611***			
		(0.195)	(0.195)			
Error rate at baseline (cent.)					0.323***	0.322***
					(0.045)	(0.045)
Worry at baseline (cent.)			0.156*			0.002
			(0.083)			(0.002)
Constant	14.098***	14.055***	14.144***	0.129***	0.129***	0.130***
	(0.499)	(0.307)	(0.317)	(0.009)	(0.008)	(0.008)
Observations	267	267	267	268	268	268
R^2 (adjusted)	0.000	0.535	0.537	−0.003	0.222	0.220
Mean (dependent variable)	13.749	13.749	13.749	0.132	0.132	0.132

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. The dependent variable is the average calculation time in seconds or the average error rate (i.e., the fraction of incorrect answers) across all mental arithmetic problems attempted in non-news blocks. *Worry-Amplifying condition* is an indicator equal to one for subjects in the experimental condition of the same name. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

Table A.5. Matrix of Correlation Coefficients between Changes in Labor Productivity, Worry, and Happiness

Variable:	Change in worry	Change in happiness	Change in productivity
Change in worry	1.000		
Change in happiness	−0.165***	1.000	
	(0.007)		
Change in productivity	0.033	0.009	1.000
	(0.595)	(0.880)	

Notes: Matrix of Spearman's rank correlation coefficients, with two-sided p-values in parentheses. *Change in productivity* is the difference in the average number of correct answers per block between non-news blocks and baseline. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$.

Table A.6. News Salience and Labor Productivity

	Dependent variable: Correct answers per news block		
	Worry-Alleviating subsample	*Worry-Amplifying* subsample	Full sample
	(1)	(2)	(3)
COVID-19 Headlines subcondition	−0.052	0.204	−0.055
	(0.399)	(0.462)	(0.401)
Worry-Amplifying condition			0.050
			(0.468)
Worry-Amplifying condition			0.268
× *COVID-19 Headlines* subcondition			(0.606)
Correct answers at baseline (cent.)	0.821***	0.800***	0.810***
	(0.050)	(0.055)	(0.038)
Worry at baseline (cent.)	0.113	−0.083	0.005
	(0.086)	(0.110)	(0.072)
Constant	11.541***	11.446***	11.491***
	(0.334)	(0.403)	(0.325)
Observations	132	136	268
R^2 (adjusted)	0.655	0.597	0.623
Mean (dependent variable)	12.167	12.482	12.326

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. *Worry-Amplifying condition* and *COVID-19 Headlines subcondition* are indicators equal to one for subjects in the experimental conditions of the respective name. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

Table A.7. News Salience and Labor Productivity (without Controlling for Baseline Worry)

	Dependent variable: Correct answers per news block		
	Worry-Alleviating subsample	*Worry-Amplifying* subsample	Full sample
	(1)	(2)	(3)
COVID-19 Headlines subcondition	−0.057	0.209	−0.055
	(0.399)	(0.460)	(0.400)
Worry-Amplifying condition			0.046
			(0.466)
Worry-Amplifying condition × *COVID-19 Headlines* subcondition			0.268
			(0.603)
Correct answers at baseline (cent.)	0.812***	0.807***	0.809***
	(0.051)	(0.054)	(0.037)
Constant	11.487***	11.539***	11.489***
	(0.322)	(0.368)	(0.318)
Observations	132	136	268
R^2 (adjusted)	0.653	0.598	0.624
Mean (dependent variable)	12.167	12.482	12.326

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. *Worry-Amplifying condition* and *COVID-19 Headlines subcondition* are indicators equal to one for subjects in the experimental conditions of the respective name. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

Appendix B Are Emotional Responses to the Videos Driven by Changes in Beliefs?

In section Section 4.2, I document that the news video clips displayed to subjects as part of the main treatment manipulation provoke a multi-faceted negative emotional response. Especially the worry-inducing video in the *Worry-Amplifying* condition significantly increases subjects' worry about the health consequences of COVID-19 and concurrently reduces their happiness. This could either be driven by new factual information in the videos or by the conveyed feelings and emotions. I conduct two analyses with the aim to distinguish these two forces.

First, I make use of participants' self-reports about the information content of their condition's video clip. Descriptively, exactly 50 percent of subjects report in the postexperimental questionnaire that the video they have seen provided them with new information.[36] The proportion of subjects who report seeing new information is nine percentage points lower in the *Worry-Amplifying* relative to the *Worry-Alleviating* condition, but this difference is not statistically significant ($p = 0.143$ in a two-sided z-test of proportions). Thus, the information channel is only plausible for about half the sample, and even slightly less in the condition that drives the emotional response.

Second, I test whether the main treatment manipulation has a lasting effect on stated beliefs about COVID-19. In Table B.1 and Table B.2, I report estimates of the effect of watching the fear-evoking video on beliefs about the risk of a COVID-19 infection in Germany within six months of the experiment, the risk of long-term effects after an infection, the risk of death due to an infection, and the number of months until a vaccine will be available to a majority of the German population.[37]

Table B.1. Effect of the Main Treatment Manipulation on Beliefs about the Pandemic

Dependent variable:	Belief about infection risk		Belief about risk of long-term effects	
	(1)	(2)	(3)	(4)
Worry-Amplifying condition	3.059	3.970	−3.226**	−2.616
	(2.910)	(2.971)	(1.614)	(1.689)
Worry at baseline (cent.)		1.366**		0.915***
		(0.606)		(0.334)
Constant	26.008***	26.784***	12.697***	13.217***
	(2.009)	(2.012)	(1.275)	(1.282)
Observations	268	268	268	268
R^2 (adjusted)	0.000	0.015	0.011	0.034
Mean (dependent variable)	27.560	27.560	11.060	11.060

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. The dependent variable is measured in the number of individuals out of 100 who will suffer the respective outcome in Germany within six months of the experiment, unconditional in column (1) and conditional on contracting COVID-19 in column (2). *Worry-Amplifying condition* is an indicator equal to one for subjects in the experimental condition of the same name. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

[36] All participants but one report remembering what the video is about.

[37] Corresponding empirical distribution functions of the outcome variables by main experimental condition are presented in Figure B.1 to Figure B.4 below.

Table B.2. Effect of the Main Treatment Manipulation on Beliefs about the Pandemic (II)

Dependent variable:	Belief about risk of death		Belief about months till vaccination	
	(1)	(2)	(3)	(4)
Worry-Amplifying condition	−0.032	0.271	1.688*	1.781*
	(0.822)	(0.835)	(0.912)	(0.914)
Worry at baseline (cent.)		0.455***		0.140
		(0.157)		(0.208)
Constant	3.591***	3.849***	7.364***	7.443***
	(0.599)	(0.632)	(0.604)	(0.612)
Observations	268	268	268	268
R^2 (adjusted)	−0.004	0.018	0.009	0.007
Mean (dependent variable)	3.575	3.575	8.220	8.220

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. The dependent variable is measured in the number of infected individuals out of 100 who will die as a consequence of the disease in Germany for columns (1) and (2), and in the number of months until a vaccine will become available for the majority of the German population in columns (3) and (4). *Worry-Amplifying condition* is an indicator equal to one for subjects in the experimental condition of the same name. In columns (3) and (4), the dependent variable is coded as the maximum observed belief in the data (60 months) for one subject who does not believe that a vaccine will ever become available. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

In line with the provision of new information in the videos, the coefficient estimates indicate sizable belief effects of up to about 20 to 25 percent relative to the mean of the *Worry-Alleviating* condition for the risk of long-term effects and the number of months till vaccination. However, due to the large amount of heterogeneity in beliefs, only the effect on beliefs about the wait time until a vaccine becomes available is consistently significant at the ten percent level.[38] Moreover, since subjects in the *Worry-Alleviating* condition overestimate the risk of long-term health effects after a COVID-19 infection on average, the information provided in the fear-inducing video reduced beliefs about this event.

Taken together, the observed pattern of belief changes does not fit the documented emotional responses to the news video clips, suggesting that their effects are not primarily driven by information provision.

[38] One subject reported the belief that no vaccine against COVID-19 would ever be available. That subject's belief was coded as the highest number of months observed in the data, i.e., 60 months. The effect continues to be significant at the ten percent level if that subject is dropped from the sample instead.

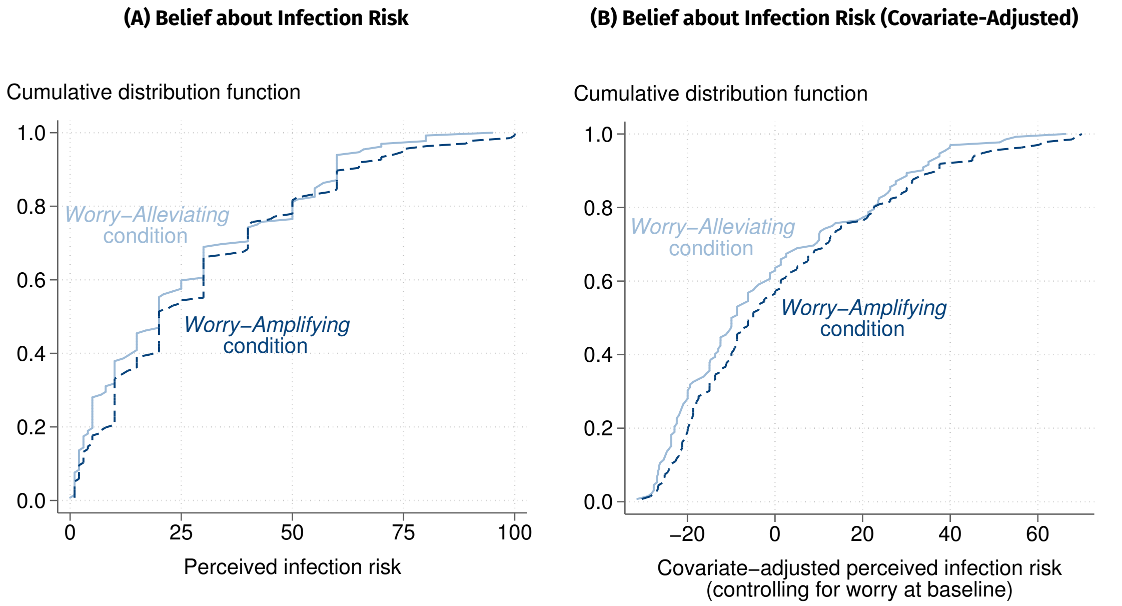


Figure B.1. Beliefs about COVID-19 Infection Risk by Experimental Condition

Notes: The cumulative distribution of beliefs about the risk of a COVID-19 infection in Germany within six months of the experiment, plotted separately for subjects in the *Worry-Amplifying* condition (dashed dark blue line) and the *Worry-Alleviating* condition (solid light blue line). Panel (A) shows the distribution of perceived infection risk in percent. Panel (B) shows the distribution of the residuals from a regression of perceived infection risk on the level of worry at baseline.

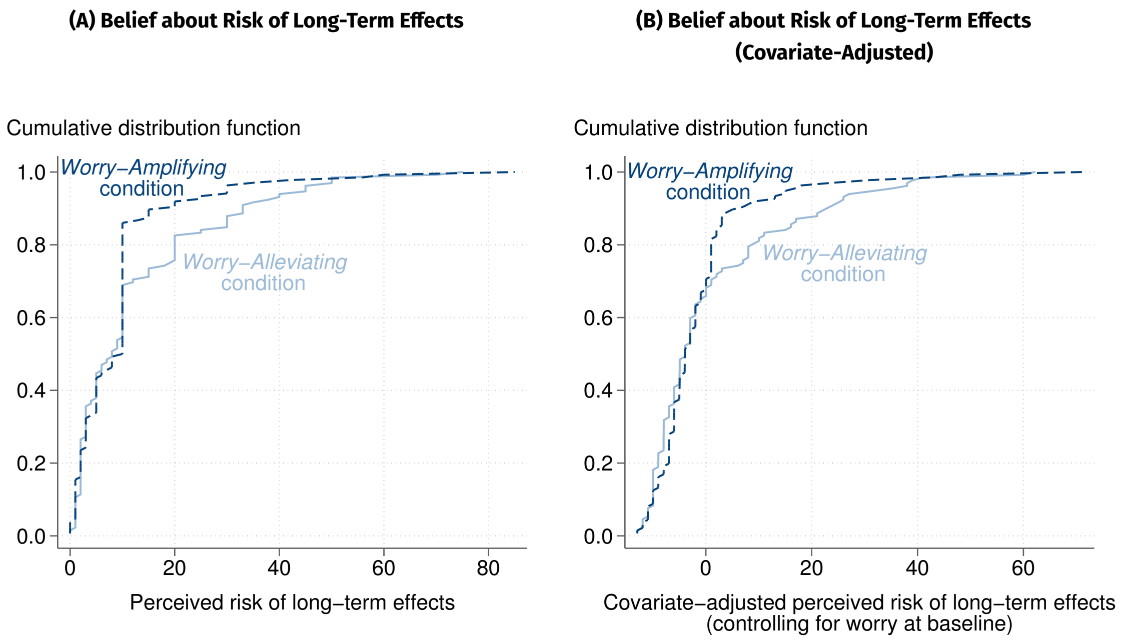


Figure B.2. Beliefs about the Risk of Long-Term Effects after a COVID-19 Infection by Experimental Condition

Notes: The cumulative distribution of beliefs about the risk that a COVID-19 infection causes long-term effects in Germany, plotted separately for subjects in the *Worry-Amplifying* condition (dashed dark blue line) and the *Worry-Alleviating* condition (solid light blue line). Panel (A) shows the distribution of perceived risk of long-term effects conditional on an infection in percent. Panel (B) shows the distribution of the residuals from a regression of the perceived risk of long-term effects on the level of worry at baseline.

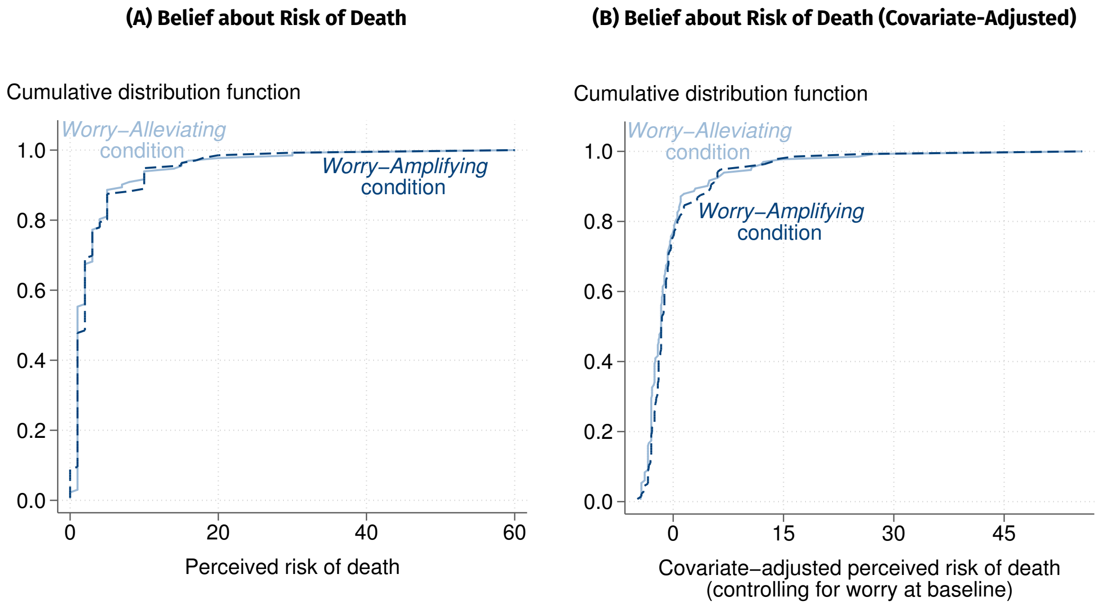


Figure B.3. Beliefs about the Risk of Death Due to a COVID-19 Infection by Experimental Condition

Notes: The cumulative distribution of beliefs about the risk of death due to a COVID-19 infection in Germany, plotted separately for subjects in the *Worry-Amplifying* condition (dashed dark blue line) and the *Worry-Alleviating* condition (solid light blue line). Panel (A) shows the distribution of perceived risk of death conditional on an infection in percent. Panel (B) shows the distribution of the residuals from a regression of perceived risk of death on the level of worry at baseline.

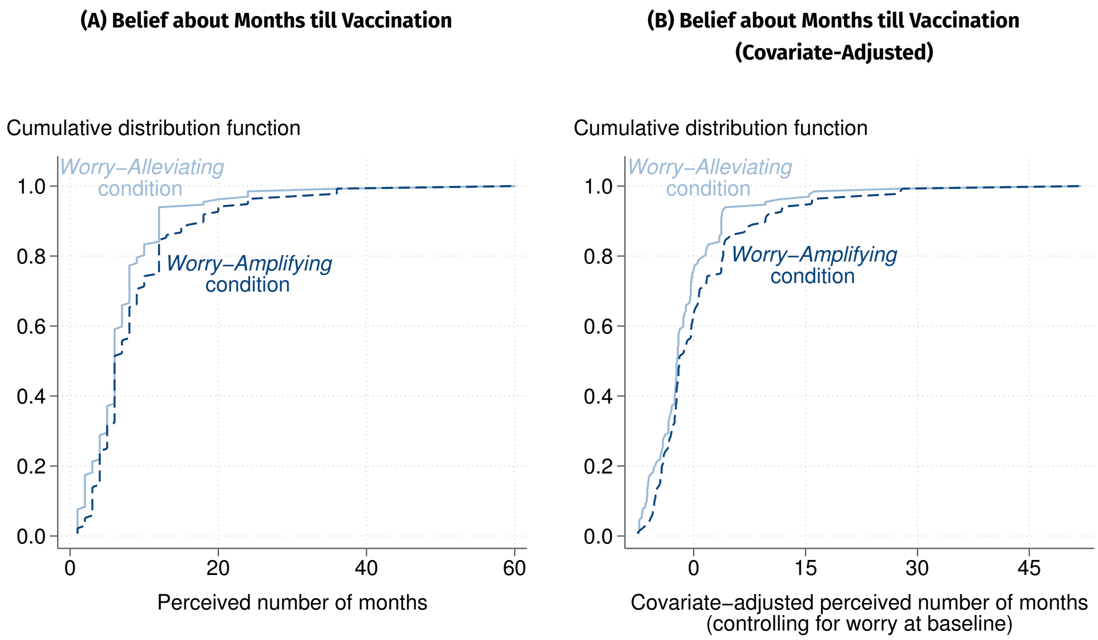


Figure B.4. Beliefs about the Number of Months until COVID-19 Vaccination by Experimental Condition

Notes: The cumulative distribution of beliefs about the number of months until a COVID-19 vaccine will be available for the majority of the German population, plotted separately for subjects in the *Worry-Amplifying* condition (dashed dark blue line) and the *Worry-Alleviating* condition (solid light blue line). The variable is coded as the maximum observed belief in the data (60 months) for one subject who does not believe that a vaccine will ever become available. Panel (A) shows the distribution of the perceived number of months till vaccination. Panel (B) shows the distribution of the residuals from a regression of the perceived number of months till vaccination on the level of worry at baseline.

Appendix C Robustness

Table C.1. Effect of the Main Treatment Manipulation on Labor Productivity in Non-news Blocks (Alternative Control Variables)

	Dependent variable: Correct answers per non-news block				
	(1)	(2)	(3)	(4)	(5)
Worry-Amplifying condition	−0.146	−0.185	−0.138	−0.267	−0.268
	(0.288)	(0.285)	(0.287)	(0.302)	(0.312)
Correct answers at baseline (cent.)	0.787***	0.780***	0.790***	0.783***	0.772***
	(0.036)	(0.035)	(0.033)	(0.034)	(0.038)
Worry at baseline (cent.)	−0.112		−0.104		
	(0.070)		(0.064)		
Happiness at baseline (cent.)			0.018		
			(0.071)		
Constant	11.291***	10.945***	11.290***	10.612***	10.594***
	(0.275)	(0.364)	(0.206)	(0.446)	(0.515)
Demographic controls	Yes	No	No	No	Yes
Baseline worry dummies	No	Yes	No	Yes	Yes
Baseline happiness dummies	No	No	No	Yes	Yes
Observations	268	268	268	268	268
R^2 (adjusted)	0.653	0.669	0.658	0.666	0.660
Mean (dependent variable)	12.058	12.058	12.058	12.058	12.058

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. *Worry-Amplifying condition* is an indicator equal to one for subjects in the experimental condition of the same name. Demographic controls include high school GPA, high school math grade, and dummies for gender, 10-year age group, highest obtained university degree (Bachelor's or Master's degree), and not reporting a GPA or math grade. Subjects who don't report a high school grade are assigned a value of 5.0, i.e., the worst possible grade. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

Table C.2. Main Results (excluding Suspected Cheaters)

Dependent variable:	Worry	Happiness	Correct answers per non-news block	Correct answers per news block
	(1)	(2)	(3)	(4)
Worry-Amplifying condition	0.711***	−1.356***	−0.186	−0.038
	(0.133)	(0.213)	(0.271)	(0.421)
COVID-19 Headlines subcondition				0.174
				(0.385)
Worry-Amplifying condition × *COVID-19 Headlines* subcondition				0.193
				(0.581)
Correct answers at baseline (cent.)			0.818***	0.856***
			(0.035)	(0.037)
Worry at baseline (cent.)	0.874***		−0.152***	−0.004
	(0.029)		(0.057)	(0.063)
Happiness at baseline (cent.)		0.600***		
		(0.067)		
Constant	6.800***	6.984***	11.040***	11.148***
	(0.081)	(0.122)	(0.188)	(0.282)
Observations	247	247	247	247
R^2 (adjusted)	0.783	0.401	0.697	0.676
Mean (dependent variable)	6.393	5.830	11.905	12.128

Notes: OLS estimates, with heteroscedasticity-robust standard errors in parentheses. 21 subjects are excluded for suspected cheating on the task according to the criteria described in Section 5.1. *Worry-Amplifying condition* and *COVID-19 Headlines subcondition* are indicators equal to one for subjects in the experimental conditions of the respective name. * denotes $p < 0.10$, ** $p < 0.05$, and *** $p < 0.01$, all for two-sided hypothesis tests.

Appendix D Experimental Instructions

This appendix reproduces the instructions of the experiment, translated from the German original. Differences between experimental conditions and explanatory remarks about specific features of the instructions or the experimental interface are indicated in brackets. For legal reasons, the elicitation of subjects' bank details was conducted at the end of the second session rather than at the beginning of the first session for subjects who participated in the second and third iteration of the experiment during the first week of December.

D.1 Instructions for Session 1

Screen 1—Welcome to the online study of the BonnEconLab.

[introductory screen with informed consent form and general information about the dates and duration of the two sessions and the payment procedure]

Screen 2—Your bank details.

[form to elicit subjects' bank details]

Screen 3—Questionnaire.

Before the start of the study, please answer the following questions:

What is your gender?

How old are you?

What is your highest level of education?

What is your current or last major?

What was your GPA in high school?

What was your last grade in math class in high school?

How would you rate your happiness at the moment? Please use a scale from 0 to 10, where 0 means "not happy at all" and 10 means "very happy".

How worried are you that COVID-19 could cause serious damage to your health or the health of your loved ones? Please use a scale from 0 to 10, where 0 means "not worried at all" and 10 means "very worried".

Screen 4—Instructions for session 1 of the study.

In this session, you can earn a payoff by solving mental arithmetic problems. You will receive €0.10 for every correctly solved problem.

There will be two blocks of 5 minutes each, during which you can solve as many problems as you like. Technically, there is a maximal number of problems, but you will not reach this limit when making a serious attempt at solving the problems.

Note: Please don't refresh the page or switch to other tabs during the mental arithmetic problems.

The sequence of events for a problem:

The sequence of events for each problem is as follows:

- First, you will see an empty white screen.

- After a few seconds, a blurry text will appear. From that point on, you can display the mental arithmetic problem by simultaneously holding down the two keys Q and ENTER (and no other key) on your keyboard. You will then see an arithmetic problem consisting of four double-digit numbers, some of which have to be added up and others subtracted.
- You are supposed to solve the displayed problem by means of mental arithmetic. The problem will be displayed as long as you keep holding down the two keys Q and ENTER.
- As soon as you release the keys Q and ENTER or press any other additional key, the problem will disappear and be replaced by an input field. You will then have **exactly 5 seconds** to type in your answer. Please only enter numbers into the input field.
- After the 5 seconds have elapsed, the input field will disappear **automatically** and the sequence of events for the next problem begins.

Note: Make sure to not accidentally activate the caps lock key ⇩ during the mental arithmetic problems.

Solution of an example problem:

Imagine that one of the mental arithmetic problems is: **65 + 11 – 37 + 29**. The correct solution to this problem is **68**. If this answer was in the input field after the 5 seconds have elapsed, you would receive a payoff of €0.10 for this problem.

You would *not* receive a payoff for this problem in the following two cases:

- if some other number was in the input field after the 5 seconds have elapsed;
- if the input field disappeared after the end of the 5 seconds before you had typed in the correct solution.

Screen 5—Comprehension questions for session 1 of the study.

Question 1:

The purpose of this question is to test whether your device meets the technical requirements for the mental arithmetic problems. There is a blurry text below this question. A number should appear in place of the blurry text when you hold down the two keys Q and ENTER (and no other key) on your keyboard. What number is displayed in place of the blurry text when you hold down the keys Q and ENTER?

Question 2:

Imagine that one of the mental arithmetic problems in session 1 of the study is: **31 – 12 + 19 + 53**. What is the correct solution to this problem, for which you would receive a payoff of €0.10?

Question 3:

What would be your total payoff from the first session of the study if you answered 18 mental arithmetic problems correctly and 6 problems incorrectly during the two blocks?

◯ €0.00

◯ €1.80

◯ €2.40

◯ impossible to tell

Screen 6.

Block 1 will start in a few seconds.

Screen 7.

[first 5-minute block of mental arithmetic problems]

Screen 8—Break.

[a relaxing image is displayed for 30 seconds]

Screen 9.

Block 2 will start in a few seconds.

Screen 10.

[second 5-minute block of mental arithmetic problems]

Screen 11—End of the first session of the study.

You have successfully completed the first session of the study.

The link to start the second session of the study will be sent to you via e-mail **tomorrow, [date],** at about 6:15. The second session will have to be completed until 23:59.

D.2 Instructions for Session 2

Screen 1—Welcome to the second session of the study.

[introductory screen]

Screen 2—Instructions for session 2 of the study.

This session of the study consists of two parts.

Information about part 1:
In part 1, you will watch a short media report about a current issue. Afterwards, there will be a question about the content of the media report. You will have **60 seconds** to answer the question.
For this part, you will receive a payoff of €4.00.

Information about part 2:
In part 2, you can once again earn a payoff by solving mental arithmetic problems. The rules will be the same as in session 1 of the study. You will receive €0.10 for every correctly solved problem.
There will be four two blocks of 5 minutes each, during which you can solve as many problems as you like.
Note: Please don't refresh the page or switch to other tabs during the mental arithmetic problems.

The sequence of events for a problem in part 2:
The sequence of events for each problem is as follows:

- First, you will see an empty white screen.
- After a few seconds, a blurry text will appear. From that point on, you can display the mental arithmetic problem by simultaneously holding down the two keys Q and ENTER (and no other key) on your keyboard. You will then see an arithmetic problem consisting of four double-digit numbers, some of which have to be added up and others subtracted.
- You are supposed to solve the displayed problem by means of mental arithmetic. The problem will be displayed as long as you keep holding down the two keys Q and ENTER.

- As soon as you release the keys Q and ENTER or press any other additional key, the problem will disappear and be replaced by an input field. You will then have **exactly 5 seconds** to type in your answer. Please only enter numbers into the input field.
- After the 5 seconds have elapsed, the input field will disappear **automatically** and the sequence of events for the next problem begins.

Note: Make sure to not accidentally activate the caps lock key ⇩ during the mental arithmetic problems.

Special feature in part 2:

Sometimes, headlines of current news articles will be displayed to you for about 10 seconds in between two mental arithmetic problems. Meanwhile, the timer for solving problems will be paused. Whether and when you will see headlines doesn't depend on your decisions.

If you want to read one of the displayed news articles, you can bookmark it for later by clicking the button "Save this news article". Bookmarked news articles will be redisplayed to you **at the end of the study**.

Screen 3—Comprehension questions for session 2 of the study.

Question 1:

This question tests whether you can hear played sounds with your device. Please play back the following audio file. What number is stated in the recording?

Question 2:

The purpose of this question is to test whether your device meets the technical requirements for the mental arithmetic problems. There is a blurry text below this question. A number should appear in place of the blurry text when you hold down the two keys Q and ENTER (and no other key) on your keyboard. What number is displayed in place of the blurry text when you hold down the keys Q and ENTER?

Question 3:

Imagine that one of the mental arithmetic problems in part 2 is: **29 + 11 + 93 – 22**. What is the correct solution to this problem, for which you would receive a payoff of €0.10?

Imagine the following situation:

After a mental arithmetic problem in part 2, the following headline is displayed to you:

[screenshot of a screen with a headline]

The following two questions both refer to this situation. For each question, exactly one answer is correct.

Question 4:

What will happen if you click the button "Save this news article"?

◯ The news article will pop up immediately.

◯ The headline will disappear after about 10 seconds and the next mental arithmetic problem will start. Apart from that, nothing will happen.

◯ The headline will disappear immediately and the next mental arithmetic problem will start. Apart from that, nothing will happen.

◯ The headline will disappear after about 10 seconds and the next mental arithmetic problem will start. The news article will be redisplayed at the end of the study for me to read.

Question 5:

What will happen if you **don't** click the button "Save this news article"?

◯ The news article will pop up immediately.
◯ The headline will disappear after about 10 seconds and the next mental arithmetic problem will start. Apart from that, nothing will happen.
◯ The news article will be redisplayed at the end of the study for me to read.

Screen 4—Part 1.

[introductory sentence in the *Worry-Alleviating* condition:] Please watch the following video, which provides information about the current state of the preparations for vaccinations against COVID-19 in Germany.

[introductory sentence in the *Worry-Amplifying* condition:] Please watch the following video, which provides information about possible health damage caused by COVID-19.

Please click here in case the video doesn't load. [If subjects click on this text, they are instructed to watch the video on a linked external website.]

[embedded video player]

Please click "Continue" when you are done.

Screen 5—Question about the video.

[in the *Worry-Alleviating* condition:] According to the video, when could it be possible to carry out protective vaccinations against COVID-19 in Germany?

◯ only in a couple of years
◯ in summer 2021
◯ already in a few weeks

[in the *Worry-Amplifying* condition:] Which potential long-term health effects of COVID-19 are mentioned in the video?

◯ No long-term health effects are mentioned.
◯ Fatigue and shortness of breath can still occur after recovery.
◯ Even in individuals without pre-existing conditions, COVID-19 can cause muscle paralyses, strokes, and brain damage, among other things.

Screen 6—Part 1.

How would you rate your happiness at the moment? Please use a scale from 0 to 10, where 0 means "not happy at all" and 10 means "very happy".

How worried are you that COVID-19 could cause serious damage to your health or the health of your loved ones? Please use a scale from 0 to 10, where 0 means "not worried at all" and 10 means "very worried".

In the following part of the study, you will be able to earn an additional payoff by solving mental arithmetic problems. How many problems per block do you want to solve correctly?
Note: In session 1 of the study, you answered [average] mental arithmetic problems per block correctly on average.

Screen 7—Part 2.

This part is divided into four blocks, each of which is 5 minutes long. During this time, you can once again solve mental arithmetic problems that consist of adding and subtracting four double-digit numbers. You will receive €0.10 for every correctly solved problem.

Sometimes, headlines of current news articles will be displayed to you for about 10 seconds in between two problems. If you want to read one of the displayed news articles, you can bookmark it for later by clicking the button “Save this news article”. Bookmarked news articles will be redisplayed to you **at the end of the study**.

Note: If you don’t click “Continue” before that, the first block will automatically start in **[countdown from 60]** seconds.

Screen 8.

Block 1 will start in a few seconds.

Screen 9.

[first 5-minute block of mental arithmetic problems]

Screen 10—Break.

[a relaxing image is displayed for 30 seconds]

Screen 11.

Block 2 will start in a few seconds.

Screen 12.

[second 5-minute block of mental arithmetic problems]

Screen 13—Part 2.

The first two blocks of mental arithmetic in part 2—block 1 and block 2—are over!

Do you think that you have solved more or fewer problems correctly on average in these two blocks than *yesterday in session 1 of the study*?

Note: Yesterday, you answered [average] problems per block correctly on average.

◯ In the two blocks now, I have on average solved fewer problems correctly than yesterday.

◯ In the two blocks now, I have on average solved about the same number of problems correctly as yesterday.

◯ In the two blocks now, I have on average solved more problems correctly than yesterday.

Please explain your answer in one to two sentences.

Screen 14.

Block 3 will start in a few seconds.

Screen 15.

[third 5-minute block of mental arithmetic problems, occasionally interrupted by the display of news headlines]

Screen 16—Break.

[a relaxing image is displayed for 30 seconds]

Screen 17.

Block 4 will start in a few seconds.

Screen 18.

[fourth 5-minute block of mental arithmetic problems, occasionally interrupted by the display of news headlines]

Screen 19—Part 2.

The last two blocks of mental arithmetic in part 2—block 3 and block 4—are over!

Do you think that you have solved more or fewer problems correctly on average in these two blocks than *yesterday in session 1 of the study*?

Note: Yesterday, you answered [average] problems per block correctly on average.

◯ In the two blocks now, I have on average solved fewer problems correctly than yesterday.

◯ In the two blocks now, I have on average solved about the same number of problems correctly as yesterday.

◯ In the two blocks now, I have on average solved more problems correctly than yesterday.

Please explain your answer in one to two sentences.

Screen 20—Questionnaire.

Finally, please answer a couple of questions that are relevant for the evaluation of the study.

Altogether, how satisfied are you with your performance in solving the arithmetic problems during **today's** session of the study? Please use a scale from 0 to 10, where 1 means "not satisfied at all" and 10 means "very satisfied".

At the beginning of today's session of the study, you have watched a video about the new coronavirus and subsequently answered a question about this video. The following three questions all refer to this video.

Question 1:

Do you still remember the main point of the video?

◯ yes

◯ no

Question 2:

Did the video contain information that was new to you?

◯ yes

◯ no

Question 3:

Was your focus on the mental arithmetic problems during today's session of the study impaired by thoughts about the content of the video?

◯ yes

◯ no

Do you actively follow the news about the new coronavirus (besides coming across news items casually)?

◯ yes

◯ no

Screen 21—Questionnaire (page 2).

Imagine that you could earn an additional payoff by working on a task. The task consists of alternately pressing the keys X and Y on your keyboard. To receive the payoff, you have to press a certain number of key combinations (pressing X and Y alternately once). Assume that you need one minute for 250 combinations. How many key combinations would you press for an additional payoff of **€2.00**?

How well do the following statements describe you as a person? Please use a scale from 0 to 10, where 0 means "does not describe me at all" and 10 means "describes me perfectly".

Statement 1:
"When someone does me a favor I am willing to return it."

Statement 2:
"If I am treated very unjustly, I will take revenge at the first occasion, even if there is a cost to do so."

How worried are you about the impact of the COVID-19 pandemic on your own financial situation? Please use a scale from 0 to 10, where 0 means "not worried at all" and 10 means "very worried".

How worried are you about the impact of the COVID-19 pandemic on your job prospects? Please use a scale from 0 to 10, where 0 means "not worried at all" and 10 means "very worried".

Screen 22—Questionnaire (page 3).

What do you think? Out of 100 individuals in Germany who are currently not infected, how many will contract the new coronavirus within the next 6 months?

What do you think? Out of 100 individuals in Germany who contract the new coronavirus, how many will suffer from lasting health damage as a consequence of the disease?

What do you think? Out of 100 individuals in Germany who contract the new coronavirus, how many will die as a consequence of the disease?

What do you think? How many months will it take until a vaccine is available for the majority of the population in Germany?
Note: If you think that there won't be a vaccine, please fill in "-1".

Screen 23—Questionnaire (page 4).

[German version of the Penn State Worry Questionnaire (Glöckner-Rist and Rist, 2014)]

Screen 24—Feedback on the study.

If you want to, you can now provide feedback to the principal investigators of this study. Were the instructions clear? Did you experience difficulties in any part of the study? You can leave this field blank if you prefer not to give feedback.

Screen 25—Your payoff.

This online study is now over. Thank you for your participation!

Your payoff:
Your payoff is composed as follows:

- **€0.10** × **[count]** correctly solved arithmetic problems problems in total in sessions 1 and 2;
- **€4.00** for watching the video in session 2.

In total, you will therefore receive **[payoff]**.

You will receive your payoff by bank transfer. The bank transfer will be ordered no later than [bank transfer date], and the money should be available on your bank account a few days later.

In case of questions or problems regarding your payoff, please write an e-mail to lpcw-studie@uni-bonn.de.

Information about the coronavirus:

As part of the study, you watched a media report about the new coronavirus. Individual media reports may not cover all aspects of a given topic. Up-to-date, verified information about the coronavirus can be found on government websites. [If subjects click on this text, they are redirected to a government website with information about COVID-19.]

The news articles you bookmarked during the mental arithmetic problems:

To view bookmarked news articles, click on the respective headline. The articles will open in new tabs. [all bookmarked news headlines with the corresponding links displayed one below the other]

Appendix E Screenshots of the Experimental Interface

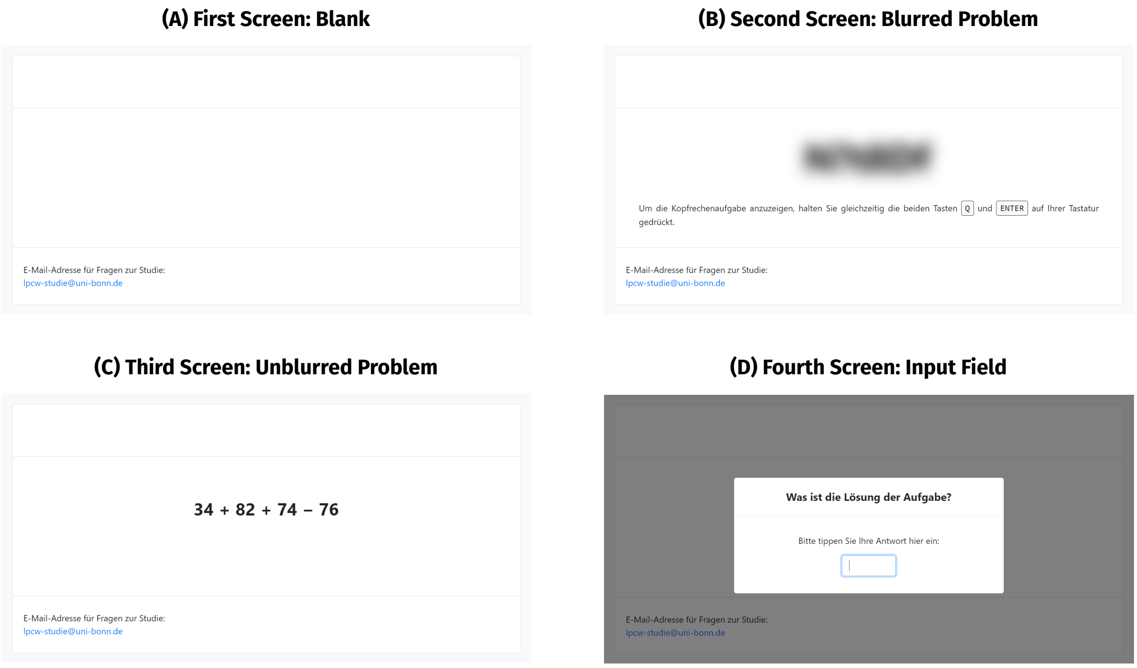


Figure E.1. Sequence of Screens for Each Mental Arithmetic Problem of the Cognitive Task

Notes: Screenshots of the experimental interface for each screen in the sequence of events for a mental arithmetic problem, with text in German. The English translations for the text on the screenshots are "To display the mental arithmetic problem, simultaneously hold down the two keys Q and ENTER on your keyboard" for panel (B) and "What is the solution to the problem? Please type in your answer here:" for panel (D). In the bottom left corner of all screens, an e-mail address for questions about the study is provided.

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