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Research Article

Listen to the Scientists: Effects of Exposure to Scientists and General Media Consumption on Cognitive, Affective, and Behavioral Mechanisms During the COVID-19 Pandemic

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Throughout the COVID-19 crisis, scientists around the globe have engaged in science communication to an unprecedented degree to convey first-hand epidemiological knowledge and information on preventive measures. The present work is aimed at empirically investigating the impact of direct exposure to scientists as compared to general COVID-19-related media consumption ($N = 698$) on central cognitive, affective, and behavioral variables, based on the extended parallel process model (EPPM) and its adaptations. A segment of the sample comprises individuals recruited independently, while others were sourced from an online panel. Importantly, this study sample was conducted at the outset of the COVID-19 pandemic. The results revealed that direct exposure to scientists positively affected recipients' knowledge and self-efficacy. General media consumption, by contrast, positively affected perceived threat as well as fear and uncertainty. Both sources positively affected the adherence to protective measures.

1. Introduction

In times of a pandemic, information can represent "the difference between life and death" [1]. The primary sources of this information are scientists, as they are capable of comprehending, investigating, and explaining scientific facts [2]. Scientific experts on pandemics are affiliated with academic disciplines, such as virology, epidemiology, medicine, and statistics, and are thus trained to understand and reflect on data and research papers about novel viruses [3]. This is crucial not only for research on potential treatments and vaccinations, but also to explain basic facts to laypersons [2]. During the coronavirus pandemic, international scientists have engaged in science communication and disseminated crucial information directly, for example, in press conferences or podcasts. It is therefore likely that more than ever before, citizens have had the opportunity to listen to scientists' explanations directly, as opposed to consuming information disseminated by the general media, which is likely to be paraphrased (e.g., on TV shows, on social media). As sources differ in how they communicate information according to their background and intent, one can assume that scientists communicate information differently to general media. For instance, research has demonstrated that media coverage in pandemics tends to be characterized by emotional content and appeals [4–6]. In turn, this may foster reactions of fear as well as perceived threat [5, 7, 8], which have been shown to be essential in the process of adhering to preventive measures in the health context.

Research on the extended parallel process model (EPPM) by Witte [9] has extensively explored the circumstances in which health information not only triggers affective and cognitive processes but also prompts behavioral responses, such as adherence to preventive measures. First adaptions of the model delved into the impact of knowledge sources (e.g., social media) on already established processes of the EPPM. Consequently, this aspect has been tailored for the current study, focusing on scientists as direct communicators, in

comparison to COVID-19-related scientific information gathered through general media consumption.

Consequently, the study is aimed at providing a better understanding into the efficacy of direct science communication efforts by researchers. It addresses two research gaps: first, by extending and applying the EPPM by Witte [9] with already established mechanisms within the COVID-19 pandemic, and second, by empirically testing the varying effectiveness between direct communication by scientists and editorially curated news consumption. This is of special importance, as more and more researchers engage in direct science communication, while empirical research on its effects is missing. Taken together, this study yields implications for both, health and science communication.

2. Theoretical Overview

2.1. Behavioral Changes During a Pandemic, on the Relevance of the EPPM. In 2020, the World Health Organization (WHO) released a document outlining a strategy to slow down the transmission of COVID-19 to prevent illness and death. The guidelines predominantly consist of behavioral interventions (e.g., physical distancing measures and frequent hand hygiene) that individuals of a community need to carry out. Behavioral change in the health context is accompanied by complex evaluations and feelings. Among other theories on behavioral change, Witte's widely used EPPM [9] conceptualizes the effectiveness of persuasive appeals (e.g., health messages) by identifying cognitive (self-efficacy and threat appraisals) and affective (fear) reactions that can lead to the acceptance or rejection of preventive behaviors. The interplay of threat and self-efficacy activates two processes: fear control and danger control. According to the theory, people will either search for ways to efficiently react to the danger and apply strategies such as preventive behaviors or will engage in fear control to defend themselves against the fear (e.g., through denial). The EPPM served as a functioning theoretical framework with the objective of examining compliance with preventive measures in the coronavirus pandemic [10–13].

Several adaptations to Witte's original model propose the impact of different aspects that interplay with the already established connections between cognitive and affective mechanisms. These adaptations share the same outcome variable: behavioral change, that is, the adoption of preventive behaviors (such as intentions to engage in hand washing and cough etiquette). Extensions of the original model introduced new variables (e.g., knowledge) but also a differentiation between information sources (here: general media and scientists).

As the present study is aimed at investigating how information related to the coronavirus pandemic in comparison to editorially curated media can ultimately affect under which circumstances humans adhere to preventive measures throughout a pandemic situation, the EPPM served as a basic model for the present study. Based on previous work in the realm, the basic model was extended in terms of the influence of knowledge and the mentioned sources. All components will be explained in the literature review, which will be closed with a hypothesis model that was conceptualized on the basic relations of the EPPM.

2.2. Cognitive Components: Self-Efficacy and Perceived Threat. In health communication, self-efficacy is defined as a personal evaluation of whether one is able to carry out specific recommended responses [9]. The concept is frequently operationalized by asking individuals whether they are able to avoid infection with a specific disease, whether or how well they are able to recover from a disease, or whether they are informed about a disease [14]. We additionally aimed to include the general meaning of self-efficacy, which refers to one's perceived strength and ability to overcome personal obstacles [15], described as optimistic self-beliefs [16]. In a pandemic situation, self-efficacy can refer to the ability to prevent oneself from being infected with a disease [9], but also to one's ability to overcome such a demanding time, which may be perceived as stressful, uncertain, and threatening. Indeed, an optimistic belief in the self is linked to emotional responses during a pandemic. For instance, Morelli et al. [17] investigated the effects of general self-efficacy during the first COVID-19-related lockdown in Italy, by taking a closer look at how parents and their children behaved. They found that the parents' regulatory emotional self-efficacy was positively associated with their children's emotional regulation (i.e., expressing emotions) and negatively associated with the children's lability/negativity (i.e., anger, disruptive behaviors). Regarding the severe acute respiratory syndrome (SARS) epidemic, Ho et al. [18] showed that people with lower self-efficacy experienced stronger feelings of insecurity and instability. Moreover, the optimistic belief in one's ability to overcome demanding situations is negatively associated with perceived threat and susceptibility to acquiring a disease or adhering to preventive measures throughout a pandemic [7, 19–21]. Moreover, Cattelino et al. empirically investigated the importance of self-efficacy (of adolescents) within the COVID-19 lockdown and found robust correlations between self-efficacy and positivity, as well as managing negative emotions and hedonic balance, underlining the importance within the COVID-19 pandemic [22].

Another cognitive concept that affects behavioral change when encountering information on a disease (including pandemic diseases) is perceived threat [9, 14]. According to Witte [9], perceived threat consists of perceived severity (the subjective belief about the threat's seriousness) and perceived susceptibility (the estimated probability of experiencing the threat). The concept is not only used in the context of specific health messages but also specific diseases [23]. Different empirical studies have shown that during pandemics, perceived threat is an important predictor of adherence to preventive measures (e.g., hand washing or cough etiquette [14, 20]). In a review on risk perception in the context of SARS, Leppin and Aro [24] highlighted that most studies and models conceptualized perceived threat as a cognitive measure, but it can also be an emotional phenomenon, especially as perceived threat can be related to affective aspects such as fear and uncertainty.

2.3. Affective Component: Negative Emotions (Fear and Uncertainty). Research has shown that fear and uncertainty are of central importance during a pandemic [25, 26]. Fear or anxiousness can be defined as a "negatively-valenced emotion, accompanied by a high level of arousal" [9]. There is consensus among researchers that fear motivates behavioral reactions, which can be crucial for survival (e.g., to flee or fight [27]). In a review of EPPM literature, Popova [23] demonstrated that fear itself can also affect behavioral changes. In line with this, Harper et al. [28] conducted an online study investigating predictors of behavioral change (e.g., improved hand hygiene and distancing) during the COVID-19 crisis and found that fear of COVID-19 itself was the only positive predictor. As perceived threat is defined as the personal assessment of how likely it is that oneself or a loved one will be affected by a threat, and how fatal a threat is, fear and perceived threat can be assumed to positively correlate—which Yıldırım, Geçer, and Akgül [29] empirically demonstrated. The construct of self-efficacy, however, is negatively correlated with fear. People who believe that they can master a difficult situation are less likely to be anxious about that situation (e.g., 31, for an empirical study in the context of SARS).

Another prevalent feeling during pandemic situations is uncertainty. While uncertainty can be felt, it is generally defined not as an emotion but rather as a lack of information that one seeks to remedy [30]. Uncertainty can be associated with both negative (e.g., concerned, confused) and positive feelings (e.g., joyful anticipation). Bar-Anan, Wilson, and Gilbert [30] proposed the uncertainty intensification hypothesis, which states that the feeling of "not knowing" can intensify negative emotional events. Kahneman and Tversky [31] argued that uncertainty is based on internal (referring to people's own world view) or external causes (based on the input from the world that we live in). This reasoning demonstrates how strongly uncertainty can be influenced by external factors, such as a source of information. Dunwoody [32] argues that information provided by experts has a higher value than information from social media, also because it usually diminishes feelings of uncertainty. However, due to the inherent "costs" (i.e., of finding and accessing relevant information), it appears that people often do not interact with their preferred expert source but rather consume news, for instance, shared on social media platforms as a compromise. Both sources might result in increased uncertainty, though Dunwoody [32] explained that COVID-19-related uncertainty also increased due to experts' explanations, as information sometimes had to be revised based on new developments.

Therefore, one of the goals of the present paper is to investigate whether scientists as direct communicators of information have a different effect on fear and uncertainty compared to general media consumption.

2.4. Knowledge. Information and knowledge are crucial in pandemic situations, as they serve as a foundation for evidence-based behavioral interventions helping to prevent people from becoming infected with a virus [33]. Within the EPPM, Witte [9] conceptualized a health message (frequently including information and knowledge) as an external source that initiates key affective, cognitive, and behavioral processes. However, in various model adaptations, the message was converted to general knowledge about a certain disease, presented by a specific source of information (e.g., traditional and social media in the MERS pandemic [34]). Bawazir et al. [35] clarified that being informed during a pandemic is associated with complicated epidemiological facts (e.g., transmission of the virus) and information about the prevalence and clinical manifestation of the virus.

Empirical research indicates that knowledge especially predicts adherence to preventive measures. In a study on quarantine behaviors during the Ebola or H1N1 outbreak, Webster et al. [36] found that persons who understood what (e.g., isolate themselves) and why they had to do it (e.g., to interrupt the transmission of infection via droplets) were more likely to adhere to the preventive behaviors. Parikh et al. did a study with Indian healthcare professionals and found that they had high levels of knowledge about the coronavirus, which was positively connected to the adherence to preventive measures [37]. However, other studies showed no direct effects [34]. Ranjit et al. showed that information was indeed valuable within the corona pandemic, but that especially misinformation spread via social media can have negative effects—which moreover highlights the importance of experts that communicate directly [38].

Besides the adherence to preventive measures, knowledge also affects the aforementioned cognitive components of self-efficacy and perceived threat [9]. Empirical findings on how perceived threat is related to knowledge are conflicting (see [39]), with both positive and negative correlations, or no correlations at all. This inconsistency might be explained by the different contextual factors at work: on the one hand, one cannot perceive a risk of what they do not know; hence, if knowledge is low, risk perception will be low. On the other hand, a person can have good knowledge about a potential threat but still have an unrealistic or distorted perception of risk and may therefore still engage in risky behaviors based on the so-called optimism bias [39]. This unclear relation between knowledge and risk perception has also been demonstrated with respect to other pandemic situations (e.g., [40, 41]).

With regard to the relation between knowledge and general self-efficacy, Bandura [42] noted that knowledge about a specific situation serves as an important precondition to activate the belief that one can overcome a challenging situation. By connecting knowledge with enhanced control, Zhong et al. [43] indirectly proposed a relation between knowledge and self-efficacy. As knowledge provides a sense of control because people understand what to control, how to behave, and how to stay safe during a pandemic, it might also positively affect the belief that one can master the demanding time. Maibach and Murphy [44], moreover, underlined that the relationship between self-efficacy and knowledge is central to adherence to preventive measures within the scope of health promotion, as self-efficacy "[…] mediates the application of knowledge and skills in the pursuit of behavioral attainments."

2.5. Relevant Sources of Information: Scientists as Direct Communicators of Information and General Media Consumption During Pandemics. Adaptions of the EPPM included different information sources as influential factors of whether people would adhere to health-related behaviors, such as adherences to preventive measures. While first studies investigated the impact of information gathered through social media in pandemic scenarios [5, 13, 14, 45, 46], research on the impact of scientists as direct information source in comparison to edited general news is missing. Consequently, the present study focusses on scientists as communicators of information (e.g., via podcasts or as talk show guests) and general media consumption. The latter is broadly composed of journalistic media such as news on TV and newspaper articles, websites from governmental institutions, and news consumed on social media platforms.

Scientists have manifold possibilities to communicate their information to an interested audience, for example, through official press conferences of governments (e.g., Dr. Anthony Fauci, Director of the National Institute of Allergy and Infectious Diseases of the National Institutes of Health, USA). Even more immediately, some scientists use their own social media channels to communicate to an audience [47]. Also during the COVID-19 crisis, scientists have used social media platforms to inform the public directly about the virus (e.g., Twitter, such as Dr. Caitlin Rivers, @cmyeaton, Johns Hopkins Center for Health Security, USA, and podcasts, such as the science NDR Info podcast *Coronavirus Update* [48] with virologist Prof. Christian Drosten, Charité Berlin, Germany). This represents an important development of science communication [49]. In Germany, the podcast *Coronavirus Update* [48] has become hugely popular and has received several awards, providing new information about COVID-19 on a weekly basis. The science journalists (Korinna Hennig and Anja Martini) ask their own questions or questions submitted by the community, which the virologist then answers. Beyond this, scientists have been featured in different media outlets and press conferences, explaining new findings, numbers, and virological basics. Consequently, there has been a fair opportunity to receive information directly from a scientist.

While there are intersections in which recipients are directly confronted with scientists within a mass media format (e.g., when scientists are part of a discussion on TV), information by scientists as communicators differs from classic journalistic media in terms that scientists are not merely cited but deliver original statements and, therefore, have more control over what is published [50].

Within this study, the authors differentiate between information that was solely provided by scientists, for instance, through their social media accounts or other science communication platforms such as podcasts with general media formats in which the coronavirus pandemic was discussed. The main difference in this conceptualization therefore lies in the control of what the scientists can communicate directly.

In general, scientists as communicators is a relatively new phenomenon, and their role is facilitated by the interest of the broader public (as has, e.g., been observed with virologists during the pandemic [51]). Research on how information from scientists affects cognitive and affective processes during a pandemic is therefore lacking.

For general media consumption, however, there are first studies indicating which affective and cognitive processes can be affected. One frequent question is whether media coverage pushes negative feelings (e.g., panic) and creates opinions that negatively impact the public [52]. Different media analyses have found that some journalistic publications have a tendency to present worst-case scenarios and work with emotional appeals [53, 54]. Seo [34] observed that during the MERS crisis, the consumption of journalistic media was associated with negative emotions—which might, nevertheless, motivate behavior. Despite this, journalistic media also has positive effects during pandemics, such as spreading messages that facilitate self-efficacy or the feeling that one is able to overcome a difficult period [8], or positively affecting the knowledge on a relevant topic [34, 55]. Surprisingly, old and new forms of media do not seem to differ much regarding how they frame their reporting on crises: Twitter analyses suggest that information disseminated on social media includes emotional utterances [4] that have predominantly been identified as negative emotions, for example, during the MERS outbreak [5]. In terms of effects, Choi et al. [5] demonstrated that social media exposure was positively related to the formation of risk perceptions.

Utz, Gaiser, and Wolfers also conducted a study during the coronavirus pandemic in Germany and investigated the immediate impact of exposure to virologists (e.g., Prof. Christian Drosten, Charité Berlin, Germany) during the coronavirus pandemic [56]. They found that such exposure can lead to parasocial relationships, which act as a mediating factor linking exposure to both subjective and objective knowledge, comfort, and adherence to preventive measures. The present study has parallels to this and extends the knowledge by comparing effects to general media consumption.

To conclude, general media consumption and scientists as communicators of information play an important role in explaining the novel coronavirus, preventive measures, and other actualities associated with the virus. However, the effect of these two sources on the adherence to preventive measures and other central cognitive and affective mechanisms associated with it is unclear. Therefore, the present study investigated how scientists as direct communicators of COVID-19-related information and general media consumption about COVID-19 affect the cognitive and affective variables and the behavioral intention to adhere to preventive measures.

Based on literature, the following hypothesis model was derived (see Figure 1). Hypothesis 1 addresses basic relations derived from previous models (EPPM [9]) and demonstrated in empirical studies with regard to different pandemic situations. Hypothesis 2 includes knowledge about the virus as an important influence on the cognitive components of perceived threat and self-efficacy. Hypotheses 3–7 then address the influence of scientists as direct communicators and general media consumption of COVID-19-related information on relevant cognitive, affective, and intention-related variables.

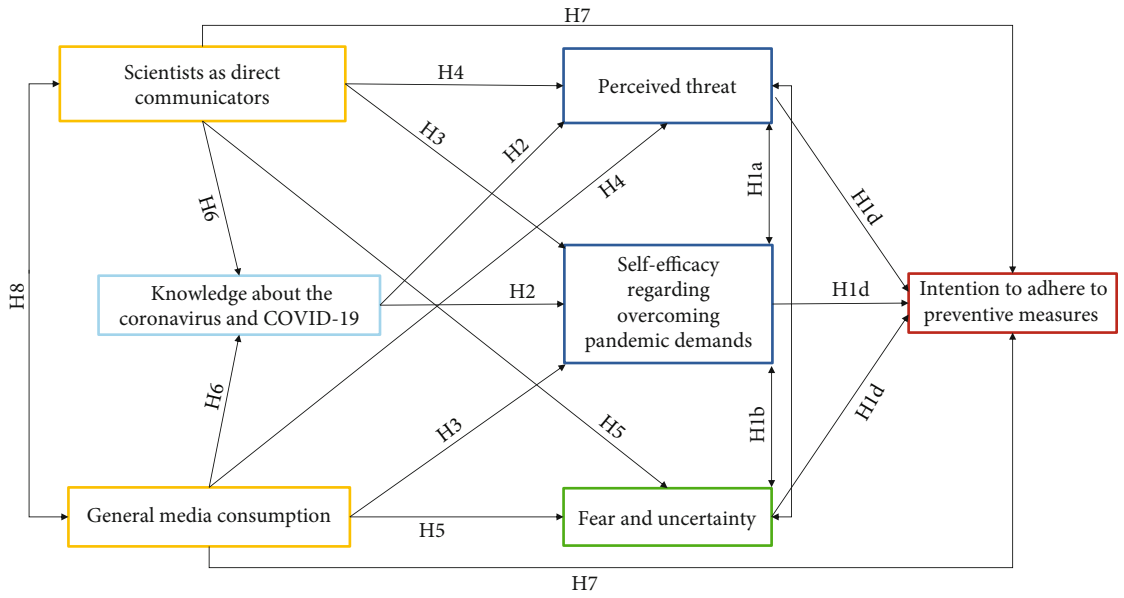

FIGURE 1: The hypothesized relations between the two information sources (yellow), knowledge (light blue), cognitive variables (dark blue), affective mechanisms (green), and the intention to adhere to preventive measures (red).

In the following, each of the hypotheses of the model in Figure 1 will be explained in more depth. The hypotheses are clustered based on cognitive/affective variables (representing the already investigated routes of the EPPM), the impact of knowledge, and then the different information sources (scientists as direct communicators versus general media consumption). Please be advised that, for clarity, the variable *self-efficacy regarding one's ability to cope with pandemic-related demands* will be referred to as "self-efficacy within the hypotheses."

To first investigate the associations between the central cognitive and affective variables derived from the literature review (mainly related to health communication research on the EPPM), the following hypotheses were formulated:

Hypothesis 1. *Self-efficacy is negatively related to (a) perceived threat and (b) fear and uncertainty. (c) Fear and uncertainty are positively related to perceived threat. (d) Perceived threat, self-efficacy, and fear and uncertainty are positively related to the intention to adhere to preventive measures against COVID-19.*

While the literature review showed that knowledge about a disease is linked to perceived threat and self-efficacy, previous findings suggest that the direction may differ according to the context of the investigation. Therefore, the following hypothesis was formulated:

Hypothesis 2. *Knowledge about COVID-19 is related to self-efficacy and perceived threat.*

The following hypotheses address the effect of information communicated via scientists and general media on the mentioned central concepts. While relevant literature supports the assumption that the source indeed affects the elaborated concepts, the directions still need to be investigated. We therefore proposed the following:

Hypothesis 3. *(a) Information about COVID-19 communicated by scientists and (b) general media consumption about the topic are both related to self-efficacy.*

Hypothesis 4. *(a) Information about COVID-19 communicated by scientists and (b) general media consumption about the topic are both related to perceived threat.*

Hypothesis 5. *(a) Information about COVID-19 communicated by scientists and (b) general media consumption about the topic are both related to fear and uncertainty.*

Hypothesis 6. *(a) Information about COVID-19 communicated by scientists and (b) general media consumption about the topic are both related to the knowledge about COVID-19.*

Hypothesis 7. *(a) Information about COVID-19 communicated by scientists and (b) general media consumption about the topic are both related to the intention to adhere to preventive measures against COVID-19.*

In addition, we formulated a hypothesis that tests basic assumptions of the hypothesis model, putting an emphasis on the relation between scientists as direct communicators and general media consumption. As scientists are also part of reports within general media [52], we derived the following hypothesis:

Hypothesis 8. *Information about COVID-19 communicated by scientists and general media consumption about the topic are related.*

3. Method

3.1. Sample. Overall, 876 persons participated in the online cross-sectional study, for which data were collected between March 28th, 2020, and April 6th, 2020. Of these, 178 participants were excluded from further analyses because they passed the survey too fast or failed the quality check questions; therefore, data of 698 respondents was included in the analyses. Participants were enlisted through two distinct methods. First, the sample included individuals recruited via an online panel ($N = 181$), and second, additional participants were self-recruited. Those sourced through the panel received compensation following panel guidelines. No individuals under the legal age were permitted to participate, and no additional quotas were used to restrict or influence the sampling process. The additionally self-recruited individuals had the opportunity to enter a lottery for one of five vouchers valued at €15. Information regarding the self-recruited sample of the study was disseminated across various channels, including local social network groups (e.g., on Facebook) and the university newsletter.

As a result, the study employs both random and convenience sampling methods. Participants were on average 36.34 years old (*range*: 16–78; SD = 15.14); 493 (70.6%) were female, 202 (28.9%) were male, and three (4.0%) considered themselves nonbinary. The sample was rather highly educated, with 294 (42.1%) participants holding a university degree and 211 (30.2%) having a higher-track secondary school leaving certificate. Three hundred eleven (44.6%) respondents were students or apprentices, and 387 (55.4%) were employed, of whom 87 (12.5%) worked in the medical sector and 69 (9.9%) in the scientific context.

3.2. Procedure, Analysis Plan, and Information on Consent. First, participants were fully briefed about the study's purpose. After providing written consent, participants were informed that the study was investigating media consumption behavior during the global COVID-19 pandemic and people's resulting perceptions of the situation. They then provided sociodemographic data and answered the questions regarding exposure to scientists and media consumption behavior, followed by questions regarding participants' knowledge about COVID-19. Participants then indicated their adherence to preventive measures as well as their negative emotions about the situation and answered questionnaires about their self-efficacy and perceived threat. The study also included further questionnaires which will not be described below as they are not part of the present analyses.

The described hypothesis model (Figure 1) was analyzed by computing a structural equation model (SEM) using IBM SPSS Amos 26. This type of analysis enables the investigation of structural connections between variables, thus allowing us to test the hypothesized associations between the relevant cognitive, affective, and behavioral variables and the intention-related variables. The procedure of the study was approved by the local ethics committee (Ethics Committee of the Department of Computer Science and Applied Cognitive Science of the Faculty of Engineering of the University of Duisburg-Essen, ID: 2003WPGM2224).

3.3. Contextual Information About the Recruitment Period. At the time of recruitment, schools and daycare centers as well as all shops in Germany (except grocery stores) had been closed since March 16, 2020. Moreover, citizens were advised to heavily restrict their contacts. There was no obligation yet to wear a face mask in public spaces, though. On March 18, 2020, the German Chancellor Angela Merkel gave her first TV speech to inform and warn people about the risks and magnitude of the COVID-19 pandemic. Further communication activities by official sources were the daily press conference of the Robert Koch Institute (the German government's central scientific institution in the field of biomedicine and infectious diseases) and the daily NDR Info podcast with Prof. Christian Drosten and science journalists Korinna Hennig and Anja Martini. Both sources are aimed at informing the public about current numbers of infections, deaths, and recoveries; new findings from recent studies; and guidance and measures on how to deal with the pandemic. At that time, it was communicated as most important to flatten the infection curve to avoid overloading the health care system.

3.4. Measures. For an overview of all items, scales, and the correlation matrix, please refer to the following link: https://osf.io/cejr9/?view_only=6536a17dc5534d4aa60d2b775c69c63a.

3.5. Sociodemographic Characteristics. In addition to age, gender, and occupation, respondents also stated their education.

3.6. General Usage of Media Regarding the Coronavirus and COVID-19. On a 5-point Likert scale (1 = *never* to 5 = *very frequently*), we assessed participants' general media usage by asking how often they informed themselves about the coronavirus through the following types of media: TV ($M = 3.36$; SD = 1.32); newspapers and magazines ($M = 3.23$; SD = 1.32); social media ($M = 2.99$; SD = 1.40); radio ($M = 2.69$; SD = 1.36); the homepage of the Robert Koch Institute ($M = 2.61$; SD = 1.27); the homepage of the German Federal government ($M = 2.01$; SD = 1.13); podcasts ($M = 1.84$; SD = 1.23); web pages of politicians, parties, or governmental institutions ($M = 1.83$; SD = 1.11); the homepage of Johns Hopkins University ($M = 1.80$; SD = 1.18); or independent web blogs ($M = 1.43$; SD = 0.82). Please note that web pages of scientific institutions (e.g., Johns Hopkins University) differ from scientists as direct communicators in terms of the presentation of information, as they reflect edited information rather than personal communication.

For each participant, we calculated a media index indicating diversity and frequency of media consumption ($M = 13.79$; SD = 5.92; *range*: 0–40). Therefore, for all 10 media types, answers concerning the frequency of use were coded according to their score on the scale (*never* = 0; *rarely* = 1; *occasionally* = 2; *often* = 3; *very frequently* = 4) and summed up so that every participant was assigned a score for every media type. The maximum possible score was 40,

if participants indicated using all 10 media types very frequently.

3.7. Exposure to Scientists as Direct Communicators of Information About the Coronavirus and COVID-19. Respondents indicated whether they had ever seen, read, or listened to media contributions by scientists most frequently represented in German media at the time of the study: Prof. Christian Drosten, Head of the Institute of Virology at the Charité Berlin; Prof. Lothar Wieler, president of the Robert Koch Institute; and Prof. Alexander Kekulé, holding the chair of Medical Microbiology and Virology at the Martin Luther University. Furthermore, participants were asked about the frequency of exposure on a 5-point Likert scale (1 = *never* to 5 = *very frequent*). Participants' responses for the three scientists were coded (*never* =0; *rarely* =1; *occasionally* =2; *often* =3; *very frequently* =4) and summed up to an index, with higher values indicating more frequent exposure to scientists ($M = 3.47$; SD = 3.12; *range*: 0–12).

3.8. Self-Efficacy Regarding Coping With Pandemic-Related Demands. To measure respondents' self-efficacy regarding the COVID-19 pandemic, we used some items derived from Yoo, Choi, and Park [14] and some self-developed items. A total of 10 items were used, including "Against the background of what I have managed to do in the past, I am not going to let myself panic because of the COVID-19 pandemic" or "I am convinced that I will be able to continue my life as best I can during the COVID-19 pandemic," rated on a 5-point Likert scale (1 = *I do not agree at all* to 5 = *I completely agree*). A factor analysis yielded a three-factor solution (explained variance: 44.94%) with the factors "coping with pandemic-related demands" ($\alpha = 0.79$), "ability to avoid infections" ($\alpha = 0.59$), and "level of information about COVID-19" ($\alpha = 0.65$). Due to reliability values and thematic fit with previous pandemic research and the general self-efficacy construct, we only used the factor self-efficacy regarding coping with pandemic-related demands for further calculations, featuring participants' abilities to survive the pandemic (four items; $M = 4.09$; SD = 0.59; $\alpha = 0.79$) (see OSF link for scale and factors).

3.9. Knowledge. Based on the procedure applied by Manika and Golden [57], participants had to indicate the correctness of 10 statements about the coronavirus (response options: true/false/do not know). Statements were adapted from WHO reports and covered both epidemiological (e.g., "The coronavirus (COVID-19) is transmitted via droplet infection") and clinical knowledge (e.g., "The incubation period of the coronavirus (COVID-19) is one to two weeks"). A sum score of correct answers was calculated, with higher values indicating a higher level of knowledge ($M = 5.66$; SD = 0.93; *range*: 0–9; *maximum*: 10).

3.10. Fear and Uncertainty. Participants' negative emotions concerning the COVID-19 pandemic were measured using the 10 negative affect items from the Positive and Negative Affect Schedule (PANAS [58]) rated on a 5-point Likert scale (1 = *not at all* to 5 = *strongly*). Factor analysis indicated a two-factor solution (explained variance: 46.31%), with the two factors "fear and uncertainty" ($M = 3.02$; SD = 0.96; $\alpha = 0.88$) and "anger" (items: angry, hostile, and irritated; $\alpha = 0.73$). Due to the role that fear and uncertainty play in pandemics, and the better reliability of "fear and uncertainty," this subscale was used for further calculations. The six items of the subscale refer to feeling concerned, terrified, nervous, confused, anxious, and uncertain.

3.11. Perceived Threat. Perceived threat was surveyed using four items, such as "I expect to become infected with the coronavirus (COVID-19) within the next three months" indicating perceived vulnerability, whereas perceived fatality was measured using items like "The coronavirus (COVID-19) is a fatal virus" ($M = 3.41$; SD = 0.65; $\alpha = 0.62$).

3.12. Intention to Adhere to Preventive Measures. In accordance with Yoo, Choi, and Park [14], we measured participants' adherence to preventive protective measures by asking "To what extent do you adhere to the following preventive measures?", followed by a list of five measures such as social distancing and hand washing. Adherence to each measure was rated on a 5-point Likert scale (1 = *not at all* to 5 = *strongly*). Mean values were calculated for the adherence to these preventive measures ($M = 4.48$; SD = 0.43; $\alpha = 0.57$).

4. Results

4.1. Relations Between the Information Sources, Knowledge, Cognitive, Affective, and Intention-Related Components: Testing the Hypothesis Model (Hypotheses 1–7). A SEM with observed variables was computed to test the derived hypothesis model (see Figure 1). The maximum likelihood method was used to evaluate the model. The goodness of fit was estimated based on parameters recommended by Hu and Bentler [59], Marsh and Hocevar [60], and Schermelleh-Engel and Moosbrugger [61]. To test the appropriateness of the model, a ratio of $c^2/\mathrm{df} < 3$ was chosen. The cut-off criterion for the nonnormed fit index (*NNFI*; also known as the Tucker-Lewis Index (TLI)) and comparative fit index (*CFI*) was 0.95. The root mean square of error approximation (*RMSEA*) value should not exceed 0.08, while the standardized root mean squared residual (*SRMR*) is defined to be below 0.05. The results revealed a good model fit, as all important parameters were in accordance with the literature: $c^2(1) = 3.12$, $p = 0.211$, $c^2/\mathrm{df} = 1.556$, CFI = 0.99, NNFI/ TLI = 0.98, *RMSEA* = 0.03, and SRMR = 0.01. Figure 2 shows the model with the respective calculations.

4.2. Relations Between Relevant Cognitive, Affective, and Intention-Related Variables and the Relation Between Information Sources (Hypotheses 1(a)–8). As a precondition for the hypothesized effects of scientists and mass media as sources of information, we tested whether the relations on adherence to preventive measures in health scenarios reported in the literature were also reflected in the present data.

The analyses confirmed a negative relation between self-efficacy regarding the ability to cope with pandemic-related

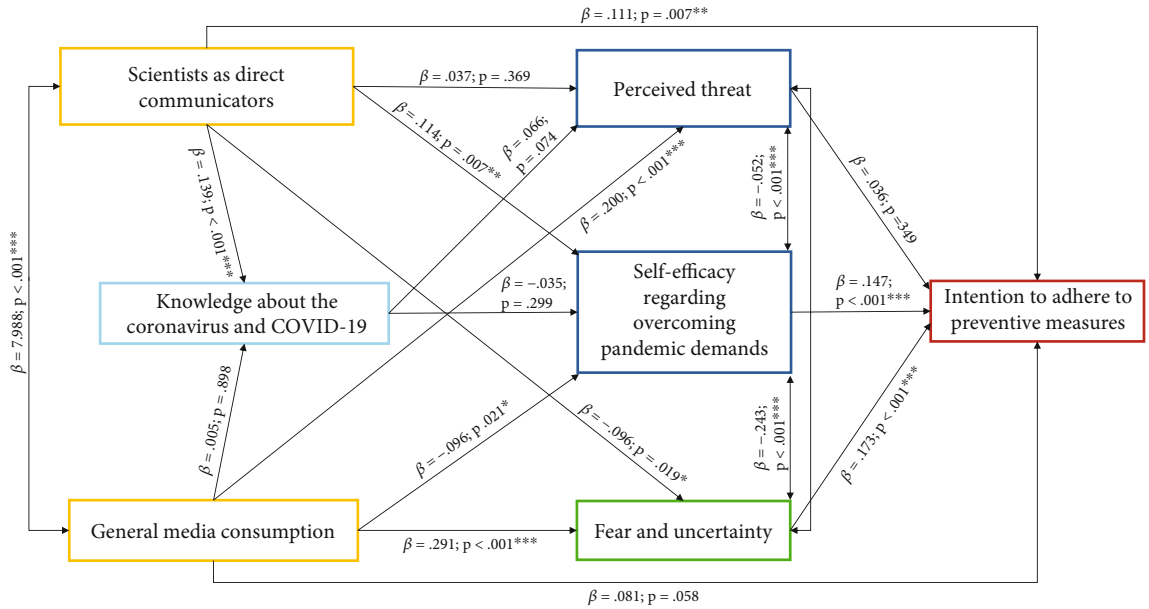

FIGURE 2: The effect of exposure to scientists and general media consumption (yellow) on knowledge (light blue), cognitive (dark blue), affective (green), and behavioral (red) components during the COVID-19 pandemic. $^{***}p \leq 0.001$, $^{**}p \leq 0.01$, $^{*}p \leq 0.05$.

demands and perceived threat ($\beta = -0.140$, *S.E.* = 0.014, $p < 0.001$). Hypothesis 1(a) was therefore confirmed. For Hypothesis 1(b), the model revealed that self-efficacy regarding the ability to cope with pandemic-related demands was negatively related to fear and uncertainty ($\beta = -0.447$, S.E. = 0.023, $p < 0.001$). This hypothesis was therefore also confirmed. Hypothesis 1(c) stated that fear and uncertainty were positively related to perceived threat, which was also supported by the present data ($\beta = 0.126$, S.E. = 0.022, $p < 0.001$). Hypothesis 1(d) focused on the relations of the cognitive and affective components with the intention to adhere to preventive measures. The analysis revealed only partially significant relations, with significant positive relations of adherence with self-efficacy regarding the ability to cope with pandemic-related demands ($\beta = 0.147$, S.E. = 0.030, $p < 0.001$) and fear and uncertainty ($\beta = 0.173$, S.E. = 0.019, $p < 0.001$). However, the cognitive component of perceived threat showed no relation with the adherence to preventive measures ($\beta = 0.036$, S.E. = 0.025, $p = 0.349$). The hypothesis can therefore only partially be confirmed.

Hypothesis 1(e) was formulated to test whether there was a relation between the information sources of scientists as direct communicators and general media consumption. The model shows that this hypothesis can be confirmed ($\beta = 7.988$, S.E. = 0.762, $p < 0.001$).

4.3. Effects of Knowledge (Hypothesis 2). The second hypothesis assumed that the knowledge about the coronavirus and COVID-19 had an influence on the cognitive processes of self-efficacy regarding the ability to cope with pandemic-related demands and perceived threat. Knowledge did not have a significant effect on self-efficacy ($\beta = -0.035$, S.E. = 0.022, $p = 0.299$) and had only a marginally significant effect on perceived threat ($\beta = 0.066$, S.E. = 0.026, $p = 0.074$). Hypothesis 2 therefore must be rejected.

4.4. Effects of Scientists as Direct Communicators of Information and General Media Consumption About the Topic (Hypotheses 3–7). Hypotheses 3 to 7 assumed that scientists as direct sources of communicating information and the general media consumption through different channels (e.g., social media, TV, or online and print newspapers) affect self-efficacy regarding coping with pandemic-related demands (Hypothesis 3), perceived threat (Hypothesis 4), fear and uncertainty (Hypothesis 5), knowledge about the virus and disease (Hypothesis 6), and preventive behavior intentions (Hypothesis 7).

The data showed that self-efficacy regarding coping with pandemic-related demands (Hypothesis 3) was negatively related to general media consumption through different channels ($\beta = -0.096$, S.E. = 0.004, $p = 0.021$) but positively affected by direct communication of scientists about the coronavirus ($\beta = 0.114$, S.E. = 0.008, $p = 0.007$). As both associations were significant, this hypothesis can be confirmed. However, the associations were in different directions.

For Hypothesis 4, the results revealed that only general media consumption was significantly positively related to perceived threat ($\beta = 0.200$, S.E. = 0.004, $p < 0.001$). Scientists as direct communicators, though, showed no significant association with the perception of threat ($\beta = 0.037$, S.E. = 0.009, $p = 0.369$). Hypothesis 4 is therefore only partly confirmed.

The data for Hypothesis 5 revealed that both general media consumption and scientists as communicators of information were associated with fear and uncertainty. This association was positive for general media ($\beta = 0.291$, S.E. = 0.007, $p < 0.001$) and negative regarding scientists as direct communicators ($\beta = -0.096$, S.E. = 0.012, $p = 0.018$). Hypothesis 5 can be confirmed, but again, the direction of influence differed.

For Hypothesis 6, the SEM showed that general media consumption was not related to participants' knowledge about the coronavirus and COVID-19 ($\beta = 0.005$, S.E. = 0.007, $p = 0.898$) but that it was positively related to scientists as direct communicators ($\beta = 0.139$, S.E. = 0.012, $p < 0.001$). The hypothesis is therefore only partly confirmed.

Lastly, for Hypothesis 7, the SEM showed that both the information provided by general media and that communicated directly by scientists were positively related to the intention to adhere to preventive measures (e.g., social distancing or hand washing). However, the relation between the intention to adhere to preventive measures and general media consumption was only marginally significant ($\beta = 0.081$, S.E. = 0.003, $p = 0.058$), while the relation with scientists as direct communicators was significant ($\beta = 0.111$, S.E. = 0.006, $p = 0.007$). Therefore, the hypothesis can be confirmed, specifically regarding scientists as direct communicators.

5. Discussion

The most important goal of this study was to analyze the impact of direct exposure to scientists, as compared to general COVID-19-related media consumption, on knowledge, self-efficacy, perceived threat, fear and uncertainty, and intention to adhere to infection prevention measures. The following discussion begins with reflecting on our results regarding already empirically established relations between core concepts within pandemic situations. This is followed by the focus of our study: the role of knowledge and information source (information communicated by scientists and information consumed via general media) on the investigated cognitive, affective, and intention-related variables.

5.1. Relations Between Relevant Cognitive, Affective, and Intention-Related Variables and Relation Between Information Sources (Hypotheses 1(a)–8). Our findings predominantly support the previously identified factors that influence the adherence to preventive measures within the health context and pandemics [9, 14, 34]. In line with previous research, self-efficacy was negatively related to perceived threat (Hypothesis 1(a)) and fear and uncertainty (Hypothesis 1(b)), matching the basic assumption that people who believe that they can cope with the pandemic are better able to handle negative affective and cognitive processes [17, 19, 62]. The data also revealed that self-efficacy is positively related to the intention to adhere to preventive measures, which underlines the importance of this variable. This association should be considered by general media, specifically regarding how the media reports on pandemic situations, as research has shown that the concept is still underrepresented [8, 63]. Moreover, in line with relevant literature (e.g., EPPM) [9, 26], our findings revealed an association between perceived threat and fear and uncertainty. Matching the notion that fear and uncertainty are not merely negative affective states but also behavior motivators [23, 28], we found a significant association with the intention to adhere to the infection prevention measures. This suggests that the findings of previous studies in the health context and other pandemic situations can also be applied to the COVID-19 pandemic.

The only relation suggested by the literature [9, 14] that we did not observe was between perceived threat and the intention to adhere to preventive measures. Because the pandemic represents an unprecedented situation for the respondents, they may have had difficulties in transferring the adherence to the mentioned preventive measures (e.g., hand washing) to how this would help to prevent the perceived threat of a pandemic.

Finally, we tested the relationship between the two information sources (scientists and general media). As predicted, and following from the fact that they are logically intertwined, the perception of scientists was highly related to general media consumption.

5.2. General Media Consumption and Exposure to Scientists: Effects on and of Epidemiological and Clinical Knowledge About COVID-19 (Hypotheses 2 and 6). The SEM showed that general media consumption does not contribute to the knowledge about the virus but that exposure to experts does increase such knowledge. This seems plausible, as scientists are trained to understand epidemiological and clinical details about the virus [3], while the mass media also cover other crisis-related aspects such as emotional appeals, case reports, or discussions (political) about recommended behaviors [6, 64]. More direct communication of scientists in the media may therefore be beneficial to educate the public about basic scientific information important during a pandemic. However, journalists are experts in their field, and it is undoubtedly also important to report information that goes beyond the epidemiological facts of a pandemic. Moreover, science journalists are trained to frame and explain scientific information, which is essential for some people for getting in touch with science. In this vein, Nelkin [65] concluded that "for most people, the reality of science is what they read in the press. They understand science less through direct experience or past education than through the filter of journalistic language and imagery." Consequently, cooperation between journalists and scientists might be especially beneficial when scientific information is crucial. In Germany, the NDR Info podcast *Coronavirus Update* [48] has gained huge popularity (41 million clicks for 40 episodes), as the science journalists have managed to navigate through relevant topics by asking the right questions to virologist Prof. Christian Drosten, who still explains the virological background knowledge in his own words.

The findings revealed that knowledge was not significantly related to self-efficacy and showed only a marginally significant association with perceived threat. This indicates that epidemiological knowledge by itself does not make people believe that they can cope with the crisis or that this knowledge affects how fatal they perceive the crisis to be. While the effect can be interpreted positively for perceived threat, as it means that mere knowledge does not cause people to panic, it also implies that knowledge on its own does not contribute to the feeling that one can master the situation and overcome the crisis. As both general media

consumption and scientists as direct communicators are related to self-efficacy, the results indicate that more is required for a person to feel self-efficacious. This is in line with research by Utz, Gaiser, and Wolfers who found positive effects of direct exposure to virologist via parasocial relations that can be built in intense times of a pandemic [56]. This is also reflected in a cited tweet within the paper stating "Professor Drosten has become the figure of #coronavid19 for me! Objective, not hectic, and comforting!" (p. 799).

Further research is necessary to identify aspects of the two sources (e.g., personality or narrative used for reports or communicated by scientists) contributing to a relation between knowledge and the feeling that one can cope with pandemic-related demands.

5.3. General Media Consumption and Exposure to Scientists: Effects on Self-Efficacy Regarding the Ability to Cope With Pandemic-Related Demands (Hypothesis 3). The SEM showed that both the general media consumption and the exposure to scientists are significantly related to self-efficacy in terms of coping with pandemic-related demands. Studies on previous pandemics have shown that mass media cover both stories that facilitate self-efficacy rather than promote fear [8] and stories that highlight worst-case scenarios [66]. Our data suggest that the effects of general media consumption are marginalized when compared to direct communication from scientists, which might be more successful in "guiding" societies through a crisis.

Surprisingly, however, we found that exposure to experts influenced both knowledge and self-efficacy but that these are not linked to each other. The obvious explanation, that by communicating knowledge, experts help to increase people's self-efficacy, therefore does not hold. Instead, scientists seem to provide something other than knowledge, which supports people's self-efficacy. Whether this is because they are seen as comparable individuals mastering the crisis themselves (vicarious self-efficacy [15]) needs to be addressed in future studies.

The negative relation between general media consumption of COVID-19-related information and self-efficacy regarding the ability to cope with pandemic-related demands requires careful consideration. While media analyses of earlier pandemics indicate that the media also try to convey messages of self-efficacy [8], part of our general media consumption index was social media usage. An analysis of Facebook during the beginning of the COVID-19 pandemic showed that social media enhanced the spread of so-called pandemic populism [66]: many shared articles emphasized how governments, political leaders, or individuals failed to deal with pandemic dangers, potentially contributing to the negative relation between general media consumption and self-efficacy in the pandemic. An additional regression analysis of the present data indeed indicated that, especially, social media consumption seems to be responsible for decreased self-efficacy ($b = -0.141$, $t(696) = -3.75$, $p > 0.001$) while the consumption of traditional media does not ($b = 0.001$, $t(696) = 0.25$, $p = 0.980$). Social media as a frequently used source of information should therefore be carefully considered in the context of pandemic situations.

5.4. General Media Consumption and Exposure to Scientists: Effects on Perceived Threat of COVID-19 (Hypothesis 4). Results revealed that general media consumption, in contrast to exposure to scientists, is significantly positively related to perceived threat of COVID-19. Intuitively, one might argue that scientists publishing pandemic-related data, such as official numbers of deaths (e.g., France's General Director for Health, Prof. Jérôme Salomon) might contribute to the perceived threat. However, perceived threat can be understood as a subjective evaluation rather than an objective statistical measure. For instance, Leppin and Aro [24] emphasized that to date, it has not been systematically investigated whether risk perception can be characterized as a cognition or an emotion. Therefore, the "hard facts" communicated by scientists may not be the crucial aspect of perceived threat, and instead, narratives reported by general media (e.g., the tendency to report worst-case scenarios) may be more important.

Although there was no direct significant association between perceived threat and the adherence to preventive measures, this variable needs to be taken seriously, as our data revealed an association of adherence with COVID-19-related self-efficacy and the feeling of fear and uncertainty.

5.5. General Media Consumption and Exposure to Scientists: Effects on Fear and Uncertainty (Hypothesis 5). While general media consumption and exposure to scientists were both related to feelings of fear and uncertainty during the COVID-19 crisis, general media consumption proved to be a positive predictor and exposure to scientists a negative predictor. This influence of general media consumption seems highly plausible, as analyses of both traditional and social media have revealed that press coverage and social media posts entail messages that might evoke fear and uncertainty (e.g., [54, 66]). Although the elicitation of fear might appear undesirable at first glance, fear can also be beneficial, as it can motivate behavior. Witte [9] highlighted fear as an important aspect of the persuasiveness of messages [23, 28]. In line with this, we found a significant association between negative emotions and the adherence to protective measures.

The negative relation between the exposure to scientists and fear and uncertainty might also be influenced by the positive relation between exposure to scientists and COVID-19-related self-efficacy. Listening to experts, who potentially even work towards solutions (e.g., vaccines), might positively affect the feeling of conquering the situation (self-efficacy), which in turn might positively affect a person's emotional state.

5.6. General Media Consumption and Exposure to Scientists: Adherence to Preventive Measures (Hypothesis 7). When looking at the direct paths, general COVID-19-related media consumption across different media channels does not affect the intention to adhere to preventive measures, while exposure to scientists does affect this intention. While this may initially appear to suggest a superiority of direct communication of scientists, a closer look at the data reveals that general media consumption can also help in promoting

adherence to the measures, as both sources indirectly affect adherence intentions but via different paths. While general media consumption affected more emotionally connotated mechanisms (fear and uncertainty and perceived threat), which ultimately affected the intention to adhere to the measures, the exposure to scientists rather affected cognitive processes (knowledge and self-efficacy). However, previous studies have suggested that to achieve sustainable behavior change, fear and threat as well as knowledge and self-efficacy need to be present [9, 67]. For practice, a well-orchestrated collaboration of journalists and scientists could be fruitful to foster people's compliance with measures to combat the pandemic. The NDR Info podcast *Coronavirus Update* [48] serves as a good first example of a prolific collaboration.

6. Limitations

Originally, the study was conducted using a German sample, which limits the applicability of the results concerning media exposure and scientists to other countries. However, the unique research setting was facilitated by the fact that there was direct exposure to expert knowledge in the form of the podcast described in the paper by virologist Prof. Dr. Christian Drosten in German. Future research, emphasizing the differentiation between direct science communication by scientists themselves and, conversely, mass media-presented sources of information, should include intercultural comparisons. It is essential to consider that there are likely variations in the accessibility of information across different countries.

Furthermore, participants exhibited an education level above the average, and the proportion of women exceeded that of men. It is crucial to emphasize that individual knowledge levels play a role in this model. However, it is acknowledged that individuals with a higher educational attainment may potentially possess a different approach to information sources and processing methods. Considering the widespread impact of the pandemic on society and the potential influence of education levels on media selection and processing, future studies should recognize this personal variable as a significant potential factor.

Furthermore, the data collection took place in the early stage of the pandemic, which probably results in a unique picture of the situation and reflects participants' general need for any kind of information.

In terms of participants' media consumption, the exact programs and formats consumed through the different media types were not specified. Further investigations could therefore differentiate between media types, sources, and consumed content to gain more detailed insights into individuals' media consumption behavior during a pandemic crisis.

To assess participants' exposure to scientists, we only asked about three specific scientists, though these were the most present scientists at the time of the data collection. Due to the changes in scientists' media appearances over time during the pandemic, repeated measurements and more scientists should be used to investigate long-term effects of science communication.

While the theoretical frameworks utilized were well-established, the need for new measurement approaches arose for certain scales. Drawing upon methodologies from prior studies, items were adapted to align with the pandemic circumstances. Future research stands to benefit from the wealth of existing studies, potentially leading to more robust measurement methodologies.

Overall, the effect sizes are quite small, indicating that the explained variance for the effects is rather low and probably influenced by additional factors that warrant further investigation.

7. Conclusion

Direct communication by scientists (ranging from appearances in governmental press conferences to podcasts or social media) is fundamental in influencing people's knowledge and attitudes regarding a pandemic crisis. Direct paths in the hypothesis model showed that direct exposure to scientists results in greater knowledge about the virus and higher self-efficacy compared to when consuming general media contents. Moreover, consuming information from scientists as direct communicators is significantly associated with the adherence to preventive measures. Nevertheless, general media consumption also contributes to beneficial behavior by influencing the affective measure of negative emotion as well as perceived threat. The present findings therefore demonstrate that the ways in which scientists and general media impact the individual willingness to adhere to preventive measures differ. We can therefore derive recommendations for the ongoing course of the COVID-19 pandemic and potential future pandemics and crises: first, a strong presence of directly communicating scientists is beneficial. Second, the advantages of this cognitive-based communication might be supplemented by collaboration with journalists, who have greater expertise in influencing the more affective variables helpful in making people recognize the importance of preventive measures.

Data Availability Statement

For an overview of all items, scales, and the correlation matrix, please refer to the following link: https://osf.io/cejr9/?view_only=6536a17dc5534d4aa60d2b775c69c63a. The anonymized data can moreover be sent upon request.

Disclosure

Due to the time-sensitive nature of the subject under investigation, the initial version of the paper was promptly shared as a preprint [68]. The present version of the paper has been subjected to peer review and subsequent revisions, integrating valuable insights provided by reviewers. It diverges from its previous form in terms of included analyses and a more comprehensible theoretical background. The research was performed as part of the employment at the department for social psychology: media and communication headed

by Prof. Dr. Nicole Krämer, who also functioned as an author of this work.

Conflicts of Interest

The authors declare no conflicts of interest.

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