
Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

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# Digital and physical factors influencing an individual's preventive behavior during the COVID-19 pandemic in Taiwan: A perspective based on the S–O–R model

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ABSTRACT

COVID-19 has caused considerable stress to individuals and communities. Daily press briefings on public health during the COVID-19 pandemic have increased individuals' feelings of social pressure. Abrupt changes to a person's immediate environment, such as the changes caused by COVID-19, can substantially affect their mental health and cognitive adjustment. On the basis of the stimulus–organism–response (S–O–R) framework, we examined the effects of digital and physical stimuli related to COVID-19 in Taiwan on individuals' psychological states and preventive behavior, including social distancing and personal hygiene. The data obtained from 498 valid survey questionnaires indicated that digital and physical factors including informativeness, social pressure, and severity exerted direct effects on cognitive assimilation and anxiety, which in turn affected individuals' preventive behavior. Moreover, cognitive assimilation and anxiety had significant mediating effects on the relationships of informativeness, social pressure, and severity with individuals' preventive behavior. The results of this study indicate how digital and physical stimulus factors affect cognitive assimilation and anxiety, which influence preventive behavior during a pandemic.

## 1. Introduction

COVID-19, which involves mild to severe respiratory symptoms, has overwhelmed health systems and paralyzed economies worldwide. The COVID-19 pandemic has considerably affected progress toward the 17 Sustainable Development Goals (SDGs) of the United Nations (Abidoye, Felix, Kapto, & Patterson, 2021), especially SDG 1 and SDG 8 (Elavarasan et al., 2022). This pandemic has not only disrupted the detection and treatment of infectious diseases but also increased the burden of non-communicable diseases (United Nations, UN, 2021). COVID-19 has a considerably higher basic reproduction number ($R_0$) than do other diseases caused by coronaviruses, such as severe acute respiratory syndrome (SARS), and the virus causing COVID-19 (i.e., SARS coronavirus 2, SARS-CoV-2) is infectious during its incubation period (Liu, Gayle, Wilder-Smith, & Rocklöv, 2020). To decelerate the spread of COVID-19 for alleviating its severe effects and fatal risks, countries have adopted strict and prompt public health strategies, such as shutting down nonessential services and schools, enforcing compulsory quarantine, and mandating work from home. The COVID-19 pandemic has forced governments worldwide to implement emergency procedures, such as delivering timely pandemic information; implementing preventive training programs; prohibiting gatherings; mandating citizens to wear masks; announcing movement restriction orders; closing public services, schools, and universities; and cancelling festivals and other cultural events (Beaunoyer, Dupéré, & Guitton, 2020; Farooq, Laato, & Islam, 2020). Effective quarantine arrangements and lockdowns reduce the risk of being infected with COVID-19 and limit the uncontrolled spread of COVID-19 (Yao, Tang, Fan, & Luan, 2021). However, such measures

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often cause severe disruptions, such as shortages in daily necessities, separation from family and friends, salary deductions, and social isolation, which result in the public living in an uncertain environment.

To decelerate the spread of COVID-19 among individuals and communities when vaccines or antiviral drugs are unavailable, the World Health Organization (World Health Organization, WHO, 2019) proposed the adoption of non-pharmacological public health interventions. Such interventions differ from mandatory policies, such as the closing of public institutions and the locking down of communities, because they emphasize social distancing measures, personal protective measures, travel measures, and conservational measures to decrease the rapid transmission of infection (Zickfeld, Schubert, Herting, Grahe, & Faasse, 2020). Personal hygiene (e.g., washing hands, wearing masks, and using alcoholic disinfectants) and social distancing are the most accessible protective methods against diseases for individuals (Andrasfay, Wu, Lee, & Crimmins, 2022; Kaushik, Agarwal, & Gupta, 2021) before vaccines or more effective treatments become extensively accessible. Behavioral changes among individuals and within communities should be the basis of any non-pharmacological public health strategy (Resnicow et al., 2021). Recognizing individual-level trigger factors is crucial for maximizing safety and the acceptance of preventive behavior during a pandemic.

Some research on preventive behavior has focused on psychological and demographic factors (Schmitt, Breuer, & Wulf, 2021; Troisi, Fenza, Grimaldi, & Loia, 2022; Yue, Zhang, & Xiao, 2022). For example, engagement in preventive behavior is associated with specific demographic characteristics, and media exposure, perceived effectiveness of preventive measures, and perceived seriousness of a disease are suggestively associated with engagement in preventive behavior (Chen, Ran, et al., 2020; Farooq et al., 2020). In addition, empirical research on preventive behavior (e.g., Bronfman, Repetto, Cisternas, & Castañeda, 2021; Dai et al., 2020; Song, Yao, & Wen, 2021) has focused on perceived variables, such as self-efficacy, perceived risk, attitude, and perceived behavioral control. Bronfman et al. (2021) noted that attitudes, social norms, perceived behavioral control, and knowledge levels regarding COVID-19, are critical predictors of an individual's preventive behavior. Dai et al. (2020) discovered that constructive risk communication and comprehensive pandemic information had stronger effects on preventive behavior than did rumor refutation and fake news (Li, Cui, Kaminga, Cheng, & Xu, 2022; Luo, Wang, Guo, & Luo, 2021; Wang, Chao, Yu, & Zhang, 2022). Liu (2020) validated mediating pathways regarding different types of digital media consumption to preventive behaviors and showed that COVID-19-related information across digital media directly influenced preventive behaviors. With Drouin, McDaniel, Pater, and Toscos (2020) considering the relationships between technology use and anxiety and social media, illustrating that children and parents with higher levels of anxiety were more likely to use social media and increase their technology use, finally concluding the need for social media usage by public health officials when seeking, explaining, and sharing pandemic-related information.

From 2020 to 2022, the COVID-19 outbreak, and coronavirus variants have been stressful or even harmful for individuals and communities from the potential risk of infection that has caused high amounts of uncertainty in society. Such abrupt changes to a person's immediate environment and daily life are factors that can substantially affect mental health (Choi, 2021) and cognitive adjustment (Qazi et al., 2020). For example, facing uncertain situations can increase an individual's anxiety and fear, especially when there is a potential risk for mortality and without adequate medical treatment. In order to better understand what factors trigger an individual to be more willing to comply with recommended epidemic preventive measures, two research questions are proposed: (1) What kind of contextual cues influence an individual's cognitive and emotional states during COVID-19? (2) How do contextual cues (informativeness, social pressure and severity) and internal states (cognitive assimilation and anxiety) affect an individual's preventive behavior against COVID?

The Stimulus-Organism-Response (S–O–R) model is salient to address the preceding research questions. The S–O–R model offers a set of inter-connected relationships between sensory and information stimulating (S) variables. Modern people are living in a hyperconnected metaverse with various digital and physical stimuli. An individual has to be prepared to manage such cyber-physical impacts efficiently for the benefits of healthy wellbeing among people, particularly amid COVID-19. These external environmental inputs will affect the organism's (O) cognition and emotional responses to digital and physical stimuli. The last component is identified as the responses (R) to an environment that can be considered as approach or avoidance behavior. The S–O–R model was applied to identify the types of contextual and environmental cues that influence cognitive and emotional states during the COVID-19 pandemic and how contextual cues (e.g., informativeness, social pressure, and severity) and internal states (e.g., cognitive assimilation and anxiety) affect preventive behavior against COVID-19.

Our research has three novel contributions. First, the empirical results indicate how digital and physical factors (i.e., informativeness, severity, and social pressure) influence an individual's cognitive (i.e., cognitive assimilation) and emotional (i.e., anxiety) states, which in turn influence their preventive behavior (i.e., personal hygiene and social distancing). Second, our findings indicate that cognitive assimilation and anxiety are key drivers of an individual's preventive behavior. Third, the results of this study indicate that cognitive assimilation exerts a full mediating effect on the relationship between informativeness and preventive behavior.

The remainder of this study is organized as follows. Section 2 presents a detailed review of the prior literature regarding the development of the COVID-19 pandemic and theoretical underpinning our study. Section 3 offers the development of theoretical framework and research hypotheses. In section 4, the research methods are discussed. Next, the section of data analysis and outcomes is presented in which the causal effects are identified and explained. Finally, the last section summarizes the discussion of our empirical findings, theoretical and practical implications, and conclusion of this current study.

## 2. Literature review

### 2.1. An unprecedented COVID-19 environment

Because asymptomatic people can spread COVID-19, this disease has many potential environmental risks, which has caused many governments to adopt various measures, such as strict border controls to prevent the movement of people. The experiences of countries threatened by COVID-19 in the first wave indicated that measures such as the isolation of infected populations, social distancing, quarantine, and pandemic investigation can contain the pandemic (Anderson, Heesterbeek, Klinkenberg, & Hollingsworth, 2020). Therefore, before an effective COVID-19 vaccine, adequate supplies, and medical treatments became available, nonpharmacological public health interventions were crucial in fighting COVID-19. Many governmental agencies (e.g., the Central Epidemic Command Center, CECC, in Taiwan) responsible for epidemic control have made substantial efforts to spread public health information and promote preventive action against COVID-19. These agencies are responsible for handling primary domestic information sources and the latest research reports, creating suitable information pathways across digital platform as well as for holding timely press conferences to offer the latest information to decrease the uncertainty among the population and reduce misinformation. In Taiwan, the CECC provides various types of pandemic information of COVID-19 (e.g., instruction and severity) across a number of digital channels in order to better reach, inform and educate the Taiwanese public. Taiwanese people acquire information from the CECC to understand COVID-19. The timely delivery of information, both at regular appointed conference times and updated online content helps individuals to not only understand the current situation but also to develop a more adaptive

cognitive state, which facilitates coping with a changing environment. Thus, the provision of relevant information that can be easily accessed can enable the public to understand the seriousness of the pandemic, the scope of infection, and the control measures that individuals and groups should adopt. However, related epidemic information of COVID-19 flooded various information channels (including traditional media, online, social media) and also caused different external inputs to influence the public's psychological responses to the related digital and physical stimuli.

In addition, public health departments in Taiwan issued self-health guidance. Local governments and institutions posted signs in public areas and digital spaces (e.g., QR codes) related to the importance of wearing facemasks in public, washing hands with soap, and maintaining social distancing. People worried about the COVID-19 pandemic not being controlled and about contracting or spreading this disease. The external pressure acting on people who did not follow relevant health norms in the community resulted in the creation of an unusual atmosphere, both physically and online, with intangible social pressure and estrangement between people. This external pressure might have encouraged people to follow guidelines related to hand washing, social distancing, and mask wearing in public areas (Anderson et al., 2020; Beaunoyer et al., 2020; Chen, Min, et al., 2020).

### 2.2. Theoretical underpinning: application of the S–O–R model

The stimulus–organism–response (S–O–R) model introduced by Mehrabian and Russell (1974) describes a set of interconnected relationships between sensory and information stimulating (S) variables. These external environmental inputs affect an organism's (O) cognitive and emotional responses to environmental or contextual stimuli (digital and physical factors in this study) and can manifest as feelings of control over activities, mental alertness, and enjoyment. Enjoyment and alertness are primarily emotional states, whereas control is associated with cognitive decisions (Russell & Pratt, 1980). The third variable of the S–O–R framework is the responses (R) to an environment or a context, which can be either approach or avoidance (Donovan & Rossiter, 1982; Donovan, Rossiter, Marcoolyn, & Nesdale, 1994). This framework has been extensively used to explore human behavior, especially online consumers' shopping behaviors (Xu et al., 2020). More recently, the S–O–R model has been successfully applied to examine individual's behavior during the COVID-19 pandemic (e.g., Luo et al., 2021; Pandita, Mishra, & Choi, 2021; Song et al., 2021; Soroya, Farooq, Mahmood, Isoaho, & Zara, 2021; Yang, Gu, et al., 2021; Yang, Gu, et al., 2021; Zhang, Zhang, Xiao, & Zheng, 2021; Zheng et al., 2020; Zhu, Yan, & Song, 2022) see related constructs in Table 1.

From our research context, the S–O–R model is appropriate for this current study for two reasons. First, this framework is a robust theoretical foundation for identifying potential digital and physical stimuli of COVID-19, including informativeness stimuli (e.g., information from various media) and social stimuli (e.g., social pressure and social atmosphere). Second, the framework provides sound rationales for exploring the causal relationships of an individual's internal psychological states with environmental or contextual stimulus factors and their behavior.

### 2.3. Digital and physical stimuli and COVID-19

In Taiwan, the CECC has played a critical role in explaining COVID-19 to the public as well as in providing critical information and governance to prevent the spread of misinformation. The CECC routinely produces and issues digital content related to statistical data, environmental cues about infected areas, useful preventive information, information regarding channels for those seeking help, and responses to public uncertainty. Based upon the S–O–R model, we identified informativeness, social pressure, and severity as digital and physical stimuli related to COVID-19. Informativeness is the extent to which information

**Table 1**
The related COVID-19 research based on an S–O-R perspective.

| Studies | Topic | Stimulus | Organism | Response |
|---|---|---|---|---|
| Luo et al. (2021) | This study explores peer communication situation and online sharing behavior in China. | • Peer condition<br>• Peer communication | • Fear | • Online rumor sharing |
| Pandita et al. (2021) | This study investigated the behavioral psychological changes among university students due to covid-19 crises and lockdown by qualitative research methodology. | • Economic downturn<br>• Transport disruption<br>• Online- delivery restrictions<br>• Lockdown regulations | • Academic anxiety<br>• Lockdown distress<br>• Fear<br>• Family proximity<br>• Mysophobia | • Panic-Buying<br>• E-learning<br>• Health and wellness activities<br>• Self-housekeeping<br>• Digital recreation avenues<br>• Community support<br>• Support for the Prime-minister |
| Song et al. (2021) | This study used an online survey to collect universities data in China. | • Threat of COVID-19<br>• Information overload | • Sadness<br>• Anxiety<br>• Cognitive dissonance | • Information avoidance intention<br>• Preventive behavior |
| Soroya et al. (2021) | This study used an online survey to collect adult data in Finland. | • Information source exposure<br>• Information overload<br>• Information seeking | • Information anxiety | • Information avoidance |
| Yang, Lu, et al. (2021) | This study explored a set of important influencing factors that lead to health anxiety in China. | • Dysfunctional beliefs<br>• Physical symptoms | • Metacognitive beliefs<br>• Catastrophic misinterpretation | • Health anxiety |
| Yang, Lu, et al. (2021) | This study explored patient experience unique to online pharmacy services in China. | • Emotional Support<br>• Informational Support | • Social Presence<br>• User Engagement | • Medication Adherence<br>• Diet Adherence |
| Zhang et al. (2021) | This study focused on the mobile technology users on social media platforms in China. | • Information quality<br>• Media richness | • Social media fatigue | • Negative coping |
| Zheng et al. (2020) | This study used an online survey to collect data in China. | • Pandemic Severity<br>• Governance | • Psychological Distance | • Social anxiety |
| Zhu et al. (2022) | This study analyzed the impact of the service quality of smart city system on citizen engagement in a public emergency (China). | • Information content<br>• Reliability<br>• Responsiveness | • Immediate experiences<br>• Continuous experiences | • Citizen engagement |

is provided through formal channels (e.g., the CECC) to meet receivers' needs, including contact tracing information, such as information on confirmed cases and transmission chain relationships, or prevention information from the CECC.

Studies have identified informativeness, entertainment, and advertising creativity as key success factors for the effectiveness of suitable advertisements (Lee, Sudarshan, Sussman, Bright, & Eastin, 2022; Moldovan, Steinhart, & Lehmann, 2019). Informativeness and image appeal are two crucial types of marketing stimuli because they are highly likely to attract a receiver's attention and induce internal responses (Wang, Chen, Ou, & Ren, 2019). Prior research has indicated that the format of information-conveying media (including traditional media, digital and social media) is one of the critical stimulus factors (Abbasi, Rehman, Hussain, Ting, & Islam, 2021; Barreda-Ángeles & Hartmann, 2022; Beaudoin & Hong, 2021; Chen, Min, et al., 2020; Nasir, Keserel, Surgit, & Nalbant, 2021; Roux & Maree, 2021; Yue et al., 2022). The results of the aforementioned studies have demonstrated that informativeness is a critical antecedent facilitator in the formation of consumer internal psychological states and attitudes toward electronic commerce websites as well as television and social media advertising channels.

Social pressure is an individual's understanding of referent cues (such as social media posts and in person conversations from colleagues, parents, and friends) to perform a specific behavior (Ajzen, 1991, 2005, 2020). Individuals are concerned about the COVID-19 pandemic not being controlled and are afraid of contracting COVID-19 or spreading it to others. This fear has caused external forces to act on people who do not follow community norms and has resulted in the creation of a strained atmosphere of social pressure and estrangement.

Severity relates to the seriousness of a situation (Fragkaki, Maciejewski, Weijman, Feltes, & Cima, 2021). Information (including online and social media) on the severity in relation to COVID-19, including information on rising mortality rates, transmission rates of COVID-19, incubation periods, and images displayed in various media platforms, has caused severe insecurity among individuals. Information broadcasted by various channels, social networking sites, and online platforms regarding the contagiousness of COVID-19 might have raised awareness of the risk of contracting and spreading COVID-19 (Seçer & Ulaş, 2021).

### 2.4. Organism and COVID-19

The S–O–R model indicates that the stimuli embedded in environments lead to alterations in individuals' cognitive and emotional states. Unpredictable mutations of SARS-CoV-2 can threaten physical health, psychological health, and emotional wellbeing (Li, Cui, Kaminga, Cheng, & Xu, 2021). In the present study, cognitive assimilation was considered a change in an individual's cognitive state due to digital and physical stimuli. For example, when an individual wishes to understand COVID-19 fully, they might search for information online, check social media, watch televised press conferences or live streams, or listen to the radio. Individuals might acquire information from medical experts and professional agencies and then process this information through personal experience to generate a new self-view. This cognitive assimilation enables individuals to adjust their thoughts to fit their new knowledge. Thus, in this paper, cognitive assimilation was operationalized as the extent to which an individual's beliefs, attitudes, or thoughts are adjusted through the absorption and acquisition of new pandemic-related information.

In addition, we considered anxiety to be a change in an individual's emotional state caused by digital and physical stimuli. An individual might experience unpleasant psychological states, such as isolation, depression, anxiety, worry, and stress (Brailovskaia & Margraf, 2021; Cao et al., 2020; Li et al., 2021; Troisi et al., 2022; Xu et al., 2020). For example, news regarding countries, regions, and areas severely affected by COVID-19 and experiencing increasing numbers of suspected cases, confirmed patients, and deaths have prompted serious public concern regarding infection, which has increased public anxiety (Bao, Sun, Meng, Shi, & Lu, 2020; Peng, 2022). In addition, limited supplies of protective equipment, widespread news coverage, and the misreporting of information have added to anxiety and fear (Ayittey, Ayittey, Chiwero, Kamasah, & Dzuvor, 2020). Liu (2020) indicated that pandemic information seeking on social live steaming services, online news media, and social media during the outbreak of COVID-19 could stimulate intense worry. Thus, we defined anxiety as a mental state of distress in reaction to new situations and potential undesirable outcomes during the COVID-19 pandemic.

### 2.5. Responses to COVID-19

By applying the S–O–R model to our research context, we identified social distancing and personal hygiene as responses to a COVID-19-affected environment. We defined social distancing as avoidance of other people, communities, and public spaces. This term is closely connected to "physical distancing," which is a term that has been widely used by a wide range of media channels and public health agencies during the COVID-19 pandemic (Coroiu, Moran, Campbell, & Geller, 2020) but lacks widespread use in the current research context. Because the SARS-CoV-2 virus is transmitted through person-to-person contact, social distancing has become a public health practice for reducing disease transmission. Social distancing prevents people with an illness from coming into close contact with non-infected people (Pearce, 2020). We defined personal hygiene as behavior to control the spread of diseases, such as mask-wearing and hand washing. According to governmental public preventive strategies, personal preventive behavior is critical to limiting the spread of new epidemics (Li et al., 2021). Appropriate hygiene-related behavior is crucial for preventing COVID-19 infection (Chen, Min, et al., 2020).

Prior literature (e.g., Bronfman et al., 2021; Liu, 2020; Min & Yun, 2021) studied preventive behavior in the COVID-19 pandemic indicated that an individual's preventive behavior refers to measures adopted by individuals who believe they are healthy and can approach good hygiene behavior (Bronfman et al., 2021; Chen, Min, et al., 2020; Li et al., 2021) and avoid diseases with social distancing (Andrasfay et al., 2022; Coroiu et al., 2020; Pearce, 2020) for the purpose of preventing or early detection of diseases without symptoms. An individual's preventive behavior can be considered as the approach and avoidance responses to an environment. It is thus operationalized as a bi-dimensional component comprising social distancing and personal hygiene. Based upon the prior literature (e.g., Andrasfay et al., 2022; Bronfman et al., 2021; Chen, Min, et al., 2020; Coroiu et al., 2020; Li et al., 2021; Liu, 2020; Min & Yun, 2021; Pearce, 2020), the resulting responsive behavior creates a formative higher-order construct (HOC) with an individual's approach behavior (i.e., personal hygiene) and avoidance behavior (i.e., social distancing). A change in any of the behavioral dimensions can alter an individual's preventive behavior. The causal directions are from the dimensions of social distancing and personal hygiene toward the HOC (i.e., preventive behavior). Although social distancing and personal hygiene need not be highly correlated, the removal of one of these dimensions from the HOC might prevent the HOC from completely representing an individual's preventive behavior.

## 3. Development of theoretical framework and hypotheses

Drawing on the theoretical concept of the S–O–R model, we proposed a conceptual framework and the related hypotheses. The hypothesized causal relationships among the proposed constructs of our conceptual framework are depicted in Fig. 1. The proposed research model indicates that three digital and physical stimuli, namely informativeness, severity, and social pressure, affect cognitive assimilation and anxiety, which result in preventive behavior against COVID-19, including social distancing and personal hygiene.

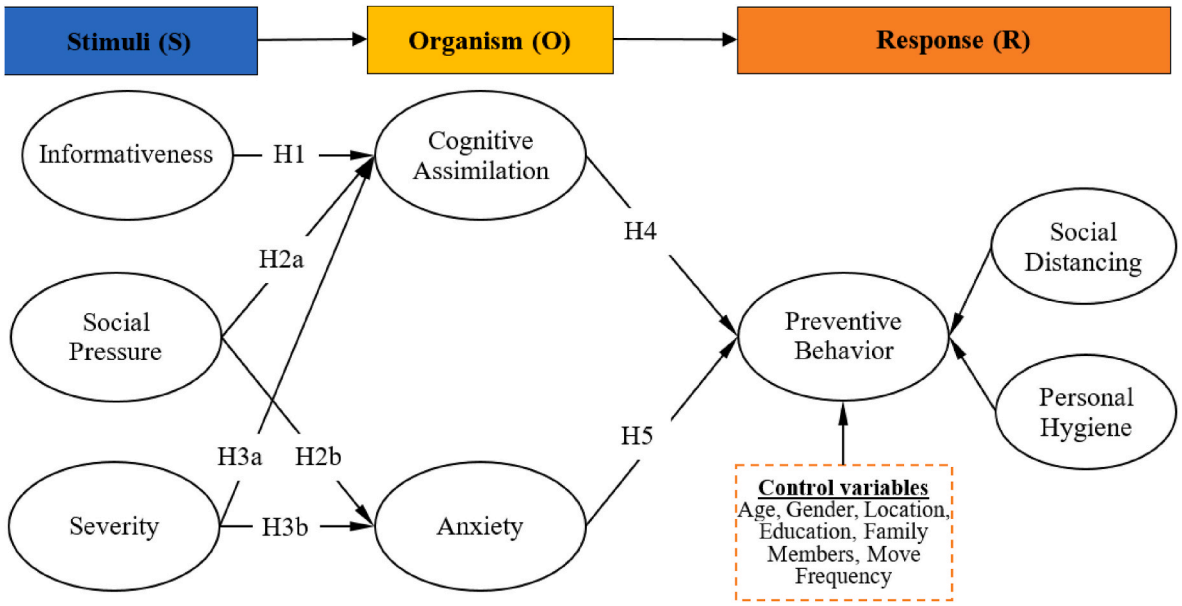


**Fig. 1.** Research model.

### 3.1. The impact of informativeness on an organism

The S–O–R model indicates that unexpected changes in the environment can affect an individual's cognitive and emotional stability, which results in behavioral changes (Donovan et al., 1994; Donovan & Rossiter, 1982). In our research context, a stimulus factor manifests the features of the COVID-19 pandemic that influence an individual's internal psychological state. Because the COVID-19 pandemic is a novel event, an individual might require additional information from a wide range of personal and official sources to understand the disease and select suitable strategies to protect themselves. During the pandemic, the frequency of information-seeking behavior from digital channels has increased among the public and if the acquired information is incorrect and invalid, confusion and uncertainty might occur among the general population. Mongkhon et al. (2021) revealed that information exposure has been saliently associated with the occurrence of anxiety, trauma, and sadness during the COVID-19 pandemic. They discovered that the strength of these associations increases with the duration of all available types of media exposure. Since the outbreak of COVID-19, the CECC in Taiwan has continually released information via online platforms, television and published media related to COVID-19 through official channels and has established mechanisms to inform people. The public are highly dependent on accurate and reliable information issued through formal channels by government agencies. The timely provision of accurate, crucial, and trustworthy information can help the public stay updated, adapt, and change their perceptions. The information provision process can result in individuals adjusting their thoughts through absorption and assimilation, which creates knowledge. Therefore, the following hypothesis was proposed:

H1. Informativeness positively affects cognitive assimilation.

### 3.2. The effect of social pressure on an organism

According to Ajzen (1991), social pressure is the social influence governing an individual's intention, and social responsibilities might affect specific behaviors. Studies have revealed the relationships of social pressure with an individual's psychological, cognitive, and affective reactions during the COVID-19 pandemic (Li et al., 2021; Schmitt et al., 2021; Yue et al., 2022). Hagger and Hamilton (2022) demonstrated that social norm factors related to colleagues, friends, and family members significantly influence an individual's preventive behavioral intention. Strong social influences are embedded within an individual's social interaction ties that might generate social pressure to influence the individual's cognitive assimilation during the COVID-19 pandemic. Considering the easy transmission of COVID-19, people have varying concerns regarding health factors related to the pandemic (Hagger & Hamilton, 2022). Social pressure is determined by people's beliefs, attitudes, and behavioral intentions and affects their decisions to engage in or not engage in a certain behavior (Ajzen, 2005, 2020). In our research context, social pressure includes being asked by other individuals to wear a mask, measuring body temperatures, staying at home when sick, and sending relevant personal information to an online contact tracing system. When individuals experience this type of broad social pressure, they may consider others' opinions and thoughts. Social pressure can help thoughts assimilate to the shared beliefs of their referent group related to performing certain psychological functions or exhibiting certain emotional states. Thus, social pressure might affect how an individual evaluates a specific situation and induce assimilation in cognition. Bronfman et al. (2021) indicated that social pressure from significant others' preventive behavior is a critical facilitator for an individual's decision to adopt preventive behaviors of personal hygiene and social distancing against COVID-19. Thus, social pressure from significant others can trigger an individual's cognitive assimilation to match the thoughts within a referent group toward preventive measures. Consequently, the following hypothesis was proposed:

H2a. Social pressure positively affects cognitive assimilation.

In addition, social pressure might cause negative psychological symptoms in an individual, including defensive attitudes, fear, and anxiety. Several studies (e.g., Aylie, Mekonen, & Mekuria, 2020; Debowska, Horeczy, Boduszek, & Dolinski, 2020; Salari et al., 2020) have been conducted on the influence of COVID-19 on people's levels of stress, depression, and anxiety. These studies have indicated that people have suffered from moderate and severe anxiety because of COVID-19 lockdowns and that the pandemic has caused mental health problems (Shah, Mohammad, Qureshi, Abbas, & Aleem, 2021). However, studies have not identified social pressure as an external factor and critical stimulus that influences anxiety. Anxiety refers to suffering and physiological feelings of excitement or extreme alertness in reaction to related digital and physical stimuli. Anxiety relates to fear, nervousness, and stress and is an aversive and unpleasant emotion (Smith & Ellsworth, 1985). Social pressure can originate from any thought or event that makes a person feel angry, nervous, or frustrated and that causes a

physiological reaction to new and challenging different digital and physical stimuli. Researchers have indicated that social pressure is often a generic precursor of anxiety disorders (Bera, Souchon, Ladsous, Colin, & Lopez-Castroman, 2022; Cao et al., 2020; Dejonckheere, Bastian, Fried, Murphy, & Kuppens, 2017). COVID-19-related information and pandemic prevention procedures can cause social pressure in daily life and are stressful antecedents of anxiety. Thus, the following hypothesis was proposed:

H2b. Social pressure positively affects anxiety.

### 3.3. The effect of severity on an organism

External digital and physical stimuli can cause an individual to exhibit physiological responses and affect their physical and mental health (Holmes & Rahe, 1967). Li et al. (2021) indicated that the severity of the COVID-19 pandemic is negatively associated with psychological health and well-being. During the initial outbreak of COVID-19, its severity triggered negative emotional reactions and mental health problems. Perceptions of the severity of COVID-19 are highly related levels of depression, obsessive–compulsive behavior, and anxiety (Aylie et al., 2020; Debowska et al., 2020; Salari et al., 2020). Subjective perceptions of infection rates might influence the psychological dimensions of subjective well-being. In general, the potential mechanisms underlying the negative effects of the severity of the COVID-19 pandemic might be related to cognitive and emotional states. A high level of severity of the COVID-19 pandemic can engender and intensify cognitive assimilation, which influences mental health and responses related to preventive actions. Because the severity of COVID-19 is relatively high and variable, it can strongly affect psychological reactions associated with cognitive and emotional states. As a result of the unprecedented COVID-19 public health crisis and the associated mental health problems related to social isolation, psychological overload, prolonged stress, and physical and mental exhaustion, the information received from significant others and governmental health agencies can trigger cognitive assimilation in adopting related preventive behavior. Thus, we proposed:

H3a. Severity positively affects cognitive assimilation.

In line with the S–O–R model, a digital and physical stimulus might trigger negative emotions and affect cognitive assessment. Studies (Fragkaki et al., 2021; Seçer & Ulaş, 2021; Shah et al., 2021) have indicated that anxiety is closely related to responsiveness to severity. In addition, in unpredictable situations, high infection risk and the uncertainty related to the curbing of the spread of COVID-19 might promote common mental health problems, such as anxiety and depression (Mongkhon et al., 2021). COVID-19 can cause severe symptoms in elderly people and people with underlying health conditions or disabilities, and effective pharmaceutical interventions, such as antiviral therapies, have not yet been developed for treating COVID-19. COVID-19 is still perceived as a deadly disease with high mortality rates among people with moderate-to-severe infections (Subramaniam, Ruf, & Bosmann, 2022). Moreover, social anxiety levels might increase as the number of COVID-19 cases increases, thus increasing the perceived risk of infection (Zheng et al., 2020). When individuals are reminded of increases in the numbers of COVID-19-infected cases and deaths, they experience increased uncertainty, nervousness, and apprehension related to their livelihoods, which leads to an increase in anxiety (European Centre for Disease Prevention and Control, ECDPC, 2020). Thus, the following hypothesis was proposed:

H3b. Severity positively affects anxiety.

### 3.4. The effect of cognitive assimilation on an individual's preventive behavior

Throughout the COVID-19 pandemic, the Taiwanese government has held daily press conferences and used various traditional and digital media channels to inform the public of measures that they can adopt to control the pandemic. The government has also highlighted the range of support offered to communities and individuals. The provision of easily accessible information might have resulted in a cognitive assimilation process in which individuals began to develop an emotional or cognitive group awareness of preventive measures (Schneider, Beege, Nebel, Schnaubert, & Rey, 2021). Individuals can access and internalize pandemic-related information into mental models through cognitive learning processes. Individuals absorb information and knowledge and adjust their thoughts to change their mindsets, which is expressed through their behavior. Barrett and Cheung (2021) demonstrated that a positive causal relationship between socio-cognitive perceptions and the understanding of preventive behavior can enhance COVID-19-related knowledge acquisition. Thus, cognitive assimilation enables an individual to adopt suitable preventive measures and increases an individual's responsiveness when they engage in preventive behavior against the COVID-19 pandemic. Thus.

H4. Cognitive assimilation positively affects preventive behavior.

### 3.5. The effect of anxiety on an individual's preventive behavior

According to the S–O–R model, cognitive and emotional states determine responses. Research (Zheng et al., 2020) has indicated that the epidemic of COVID-19 has resulted in an increase in negative psychological problems. Lima et al. (2020) indicated that anxiety may have increased after the first death caused by COVID-19 because of the increased media attention and number of new cases. Zheng et al. (2020) observed that higher levels of social anxiety are associated with increases in the number of infections. They also determined that factors such as fear of infection and uncertainty regarding whether a cure will be developed result in anxiety. Thus, uncertainty can increase anxiety, especially when mortality risk exists. Increases in the number of infections, the severity of infection, and the number of deaths can worsen mental health, and urgent and strict preventive measures must be adopted to address such increases. Olapegba, Chovwen, Ayandele, and Ramos-Vera (2021) suggested that all public and private health agencies must promote COVID-19-related hygiene education and prioritize mental health to combat COVID-19. This might lead to healthy and vulnerable individuals engaging in preventive behavior because social distancing and personal hygiene are the key to reducing infection risk and increasing awareness of the pandemic (Reiss, Franchina, Jutzi, Willardt, & Jonas, 2020). Showed that COVID-19-related information across digital channels was directly associated with preventive behaviors. Thus.

H5. Anxiety positively affects preventive behavior.

## 4. Research methodology

### 4.1. Measurement development

To test the proposed research framework and hypotheses, we developed an instrument to collect empirical data in a web-based large scale survey. Survey questions to measure the related constructs were developed on the basis of the literature. All scale items of the proposed major latent variables and the related literature are tabulated in Appendix A. Some items were slightly modified to fit the research context of COVID-19. A five-point Likert scale was applied to evaluate the survey items. To ensure the content validity of the survey instrument, several rounds of interviews with experts on the subject and a small-scale pilot test were conducted. Data from the interviews with the experts were recorded to modify the wording and ensure the suitability of the scale items. A total of 12 academics and professionals were invited to participate in the pilot test. Their answers were used to estimate content validity ratios to ensure the content validity of the survey instrument. The formal questionnaire comprised three parts: instructions for questionnaire filling, questions on participant demographics, and questions on the constructs of our research model. We controlled for numerous

demographic variables that might have affected participants' answers to the survey questions, including age, gender, location, education level, family members, and move frequency.

### 4.2. Empirical data collection

We used the cloud service provided by a free online survey platform (https://www.surveycake.com/en/) to collect empirical data from October 16 to October 30, 2021, during which time Taiwan had a level two alert for COVID-19. At that time, the pandemic in Taiwan was at its most rigid period and can best reflect the causal relationships between the public's digital and physical stimuli, psychological feelings and response to pandemic prevention behavior. The survey was based on a six-age-layer stratified sampling of the Taiwanese population. Respondents satisfied following criteria: (1) currently living in Taiwan, (2) aged 18 years or older, (3) able to read and understand Mandarin, and (4) answering over 60 s. To increase respondents' willingness to participate in our survey, we randomly provided electronic cash to 5% of the participants at every age level. To ensure high data quality, an attention check question was included to examine whether a participant had paid attention to the survey questions. If the participants provided incomplete responses to all the questions, their questionnaires were automatically disregarded. We touched 1680 visitors and collected 925 questionnaires. Finally, after incomplete or invalid questionnaires were eliminated, 498 valid questionnaires remained analysis. Table 2 presents the demographics of the respondents.

## 5. Data analysis and outcomes

### 5.1. Measurement properties

We applied partial least squares structural equation modeling (PLS-SEM) to validate the proposed research framework because of its ability to evaluate a measurement model with a strong theoretical confirmatory orientation. In addition, the partial least squares method is merited when higher-order constructs (HOCs) are included in the structural model (Hair, Hult, Ringle, & Sarstedt, 2022). In addition, this method is superior to the traditional regression method when new scales are used. SmartPLS 3.0 was used in this study to examine the measurement model and validate the structural model of the proposed nomological framework (Ringle, Wende, & Becker, 2015). The loadings, reliability, and validity of the latent variables were validated through confirmatory factor analysis (CFA). As can be seen in Table 3, the factor loadings for all scale items were greater than the threshold value of 0.708 indicating the acceptable reliability of the reflective constructs (Hair et al., 2022).

The coefficients of average variance extracted (AVE) and composite reliability of all the latent variables of our research model exceeded the relevant thresholds, which ensured that the proposed constructs had convergent validity (Table 4). The composite reliability and Cronbach's alpha (α) values of all the constructs were above 0.70, and the AVE values of all the constructs were above 0.50; thus, the reflective constructs had acceptable reliability and internal consistency (Chin, 1998; Hair et al., 2022). To examine the discriminant validity, the square roots of the AVE values of the constructs were compared with the correlations between the constructs (Table 4). The square roots exceeded all the correlation coefficients; thus, the constructs had sufficient discriminant validity. Comparing the loading of a measurement item on its latent variable to the related cross-loadings on other variables, all measures loaded more strongly on their corresponding latent variables than they cross-loaded on other variables (see Appendix B). Collectively, the CFA results demonstrate that there are no major measurement issues regarding the hypothesized constructs.

**Table 2**
Demographic information of the respondents (n = 498).

| Variable | Classification | Frequency | Percent (%) |
|---|---|---|---|
| Gender | Male | 183 | 36.7 |
| | Female | 315 | 63.3 |
| Age | 18–24 | 57 | 11.4 |
| | 25–34 | 102 | 20.5 |
| | 35–44 | 120 | 24.1 |
| | 45–54 | 119 | 23.9 |
| | 55–64 | 78 | 15.7 |
| | Above 65 | 22 | 4.4 |
| Location in Taiwan | North area | 210 | 42.17 |
| | Middle area | 50 | 10.04 |
| | South area | 203 | 40.76 |
| | East area | 28 | 5.62 |
| | The outlying island area | 7.0 | 1.41 |
| Education level | Middle school | 2 | 0.4 |
| | High school/College | 70 | 14.1 |
| | University | 296 | 59.4 |
| | Graduate/Post-graduate | 130 | 26.1 |
| Annual income (NTD $) | Less than 300,000 | 112 | 22.5 |
| | 300,001–500,000 | 111 | 22.3 |
| | 500,001–800,000 | 136 | 27.3 |
| | 800,001–1,000,000 | 75 | 15.1 |
| | 1,000,001–1,500,000 | 51 | 10.2 |
| | 1,500,001–2,000,000 | 7 | 1.4 |
| | More than 2,000,000 | 6 | 1.2 |
| Family members | Only one person | 49 | 9.8 |
| | Two persons | 90 | 18.1 |
| | Three persons | 113 | 22.7 |
| | Four persons | 157 | 31.5 |
| | More than five persons | 89 | 17.9 |
| Move frequency | 0 times by month | 104 | 20.9 |
| | 1–3 times by month | 277 | 55.6 |
| | 4–6 times by month | 64 | 12.9 |
| | 7–9 times by month | 19 | 3.8 |
| | More than 10 times by month | 34 | 6.8 |

### 5.2. Structural model validation

A significant path coefficient of 0.39 ($p < .01$) was observed for H1; thus H1 was supported (Fig. 2). This result suggests that people who perceive higher levels of informativeness are more likely to assimilate information cognitively into their preventive behavior. Significant path coefficients of 0.13 ($p < .01$) and 0.21 ($p < .01$) were observed for H2a and H2b, respectively; thus, these hypotheses were supported. These results indicate that the antecedent of social pressure affects an individual's perception of cognitive assimilation, their anxiety, and their preventive behavior. Significant path coefficients of 0.21 ($p < .01$) and 0.41 ($p < .01$) were observed for H3a and H3b, respectively; thus, these hypotheses were supported. These results indicate that an individual's perception of severity affects their cognitive assimilation and anxiety caused by COVID-19. In addition, significant path coefficients of 0.24 ($p < .01$) and 0.37 ($p < .01$) were observed for H4a and H4b, respectively; thus, these hypotheses were supported. These results indicate that cognitive assimilation and anxiety significantly affect an individual's preventive behavior during the COVID-19 pandemic in Taiwan. None of the control variables except gender significantly affected preventive behavior. Gender significantly affected preventive behavior, with women being more willing to engage in preventive behavior than were men.

The direct and indirect effects of the antecedents in the research model collectively accounted for 31.6% of the variance in preventive behavior against COVID-19. A total of 28.6% of the variance in cognitive assimilation was explained by informativeness, social pressure, and anxiety. In addition, 29.1% of the variance in anxiety was predicted by social pressure and severity. The significant path coefficients between the factors in the research model provide robust evidence for the nomological validity of the conceptual framework. In summary, the nomological framework of our research model can provide strong explanatory power for preventive behavior in response to the COVID-19 pandemic in Taiwan.

**Table 3**
Descriptions and confirmatory factor loadings of scale items.

| Construct | Item | Scales | Mean | SD | Loading |
|---|---|---|---|---|---|
| Informativeness (IN) | IN1 | I think the epidemic information from the CECC is timely (such as releasing the latest information at a daily fixed time). | 3.76 | 0.95 | 0.80 |
| | IN2 | I think the epidemic information from the CECC is understandable. | 3.80 | 0.88 | 0.84 |
| | IN3 | I think the contact tracing information from the CECC is thorough (such as footprints of confirmed cases and transmission chain relationships). | 3.43 | 1.00 | 0.84 |
| | IN4 | I think the contact tracing information from the CECC is reliable. | 3.59 | 0.92 | 0.86 |
| | IN5 | I think the prevention information from the CECC is helpful. | 3.91 | 0.78 | 0.85 |
| Social pressure (SP) | SP1 | Based on the environmental stimuli around me I think it is important that I should reduce face-to-face contact. | 3.69 | 0.79 | 0.81 |
| | SP2 | Based on the environmental stimuli around me I think it is important that I should reduce going out. | 4.11 | 0.81 | 0.85 |
| | SP3 | Based on the environmental stimuli around me I think it is important that I should follow the preventive rules | 4.35 | 0.72 | 0.80 |
| Severity (SE) | SE1 | I think the COVID-19 epidemic is severe. | 3.96 | 0.69 | 0.77 |
| | SE2 | I think COVID-19 can be life-threatening. | 4.04 | 0.68 | 0.87 |
| | SE3 | I think the infectiousness of COVID-19 is serious. | 4.53 | 0.62 | 0.89 |
| Cognitive assimilation (CA) | CA1 | I feel it is difficult to relax during the COVID-19 epidemic. | 3.87 | 0.71 | 0.83 |
| | CA2 | I feel uneasy about my life and work during the COVID-19 epidemic. | 3.90 | 0.66 | 0.85 |
| | CA3 | I feel anxious about emerging coronavirus variants (such as the Delta variant). | 3.91 | 0.62 | 0.73 |
| Anxiety (AN) | AN1 | I am worried about myself or my family being infected with COVID-19. | 3.72 | 0.79 | 0.84 |
| | AN2 | My thoughts on the epidemic can be influenced by public health information on epidemic prevention. | 3.69 | 0.82 | 0.86 |
| | AN3 | My thoughts of the epidemic can be influenced by understanding new information from the CECC. | 3.77 | 0.89 | 0.85 |
| | AN4 | My thoughts of the epidemic can be adjusted by experts' experiences (such as doctors). | 4.12 | 0.84 | 0.79 |
| Social distancing (SD) | SD1 | I may reduce unnecessary contact with others. | 4.26 | 0.62 | 0.89 |
| | SD2 | I may reduce my participation in social events (such as parties and gatherings). | 4.27 | 0.69 | 0.89 |
| | SD3 | I may reduce using public transport. | 4.10 | 0.81 | 0.73 |
| Personal hygiene (PH) | PH1 | I wear a mask in the street and closed places (such as supermarkets, pharmacies) | 4.73 | 0.51 | 0.83 |
| | PH2 | I wash my hands when I get home with sanitizer or soap. | 4.46 | 0.63 | 0.80 |
| | PH3 | I cover my mouth and nose when I sneeze or cough. | 4.62 | 0.54 | 0.82 |

### 5.3. Mediation effect

To validate the mediating effects of the S–O–R mechanism, we used the approach suggested by Nitzl, Roldán, and Cepeda (2017) to examine the validity of the mediating effects of cognitive assimilation and anxiety. The assessment of our nomological network involved evaluating the significance of two direct effects, namely those of cognitive assimilation and anxiety. These effects were not included in the conceptual framework. The indirect effects of informativeness and severity through cognitive assimilation and anxiety on an individual's preventive behavior were also investigated. As indicated Table 5, the direct effect of informativeness on preventive behavior was not significant (estimate = 0.04, 95% CI [−0.02, 0.11]); the direct effects of social pressure and severity on preventive behavior were significant (estimate = 0.51, 95% CI [0.43, 0.57] and estimate = 0.09, 95% CI [0.01, 0.19], respectively). The indirect effects of informativeness, social pressure, and severity on preventive behavior through cognitive assimilation and anxiety were significant, which indicates that cognitive assimilation has a full mediating effect on the relationship between informativeness and preventive behavior. Cognitive assimilation and anxiety partially mediated the effects of social pressure and severity on preventive behavior. The mediation analysis results obtained using the method proposed by Nitzl et al. (2017) indicate that cognitive assimilation and anxiety are critical mediators of the effects of informativeness, social pressure, and severity on preventive behavior against COVID-19.

### 5.4. Common method variance bias

Because the data used in this study were collected from self-report questionnaires, common method variance bias (CMVB) was a potential concern. The possibility of CMVB should be assessed when the independent and dependent variables are measured under the same context and obtained from the same source. As per the recommendations of Podsakoff, MacKenzie, Lee, and Podsakoff (2003), we arranged the survey items to counterpoise the order of measurement for the dependent and independent variables to eliminate CMVB from the survey through two methods. First, the items for all constructs were arranged in a random order in the survey instrument. Second, the items of all the dependent variables followed (rather than preceded) the items of the independent variables. Then several statistical analyses were conducted to check for CMVB. First, we conducted a Harmon one-factor test on the principal constructs in the conceptual framework, namely digital and physical stimulus factors (i.e. informativeness, social pressure, and severity), organism factors (i.e. cognitive assimilation and anxiety), and response factors (i.e. social distancing and personal hygiene). The results of the Harmon one-factor test revealed that the greatest level of covariance explained by the first factor was 36.04%, indicating that CMVB was not a likely problem for our results. Second, we included a common method factor whose indicators included all of the principal construct indicators in PLS model and then calculated the variances of each indicator that were substantively explained by the principal construct, following the guidelines of Podsakoff et al. (2003). As shown in Appendix C, the results of CMVB demonstrated that the average

**Table 4**
Reliability and validity statistics.

| Construct | Mean | S.D. | IN | SP | SE | CA | AN | SD | PH | PB |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Informativeness (IN) | 3.70 | 0.91 | 0.84* | | | | | | | |
| 2. Social pressure (SP) | 4.18 | 0.66 | 0.25 | 0.82 | | | | | | |
| 3. Severity (SE) | 4.05 | 0.77 | 0.17 | 0.46 | 0.84 | | | | | |
| 4. Cognitive assimilation (CA) | 3.90 | 0.66 | 0.45 | 0.32 | 0.33 | 0.80 | | | | |
| 5. Anxiety (AN) | 3.83 | 0.84 | 0.11 | 0.40 | 0.51 | 0.36 | 0.84 | | | |
| 6. Social distancing (SD) | 4.21 | 0.71 | 0.21 | 0.62 | 0.39 | 0.36 | 0.45 | 0.84 | | |
| 7.Personal hygiene (PH) | 4.60 | 0.56 | 0.25 | 0.52 | 0.41 | 0.34 | 0.36 | 0.51 | 0.82 | |
| *8. Preventive behavior* (PB)** | *4.41* | *0.63* | *0.26* | *0.66* | *0.46* | *0.40* | *0.47* | — | — | *0.72* |
| Average variance explained (AVE>0.5) | | | 0.70 | 0.67 | 0.71 | 0.65 | 0.70 | 0.71 | 0.67 | 0.52 |
| Composite reliability (CR > 0.7) | | | 0.92 | 0.86 | 0.88 | 0.85 | 0.90 | 0.88 | 0.86 | 0.87 |
| Cronbach's alpha (α > 0.7) | | | 0.90 | 0.76 | 0.80 | 0.73 | 0.85 | 0.79 | 0.75 | 0.81 |

Note: * Diagonal elements are the square roots of the AVE; ** Italics used for higher-order construct (HOC, PB).

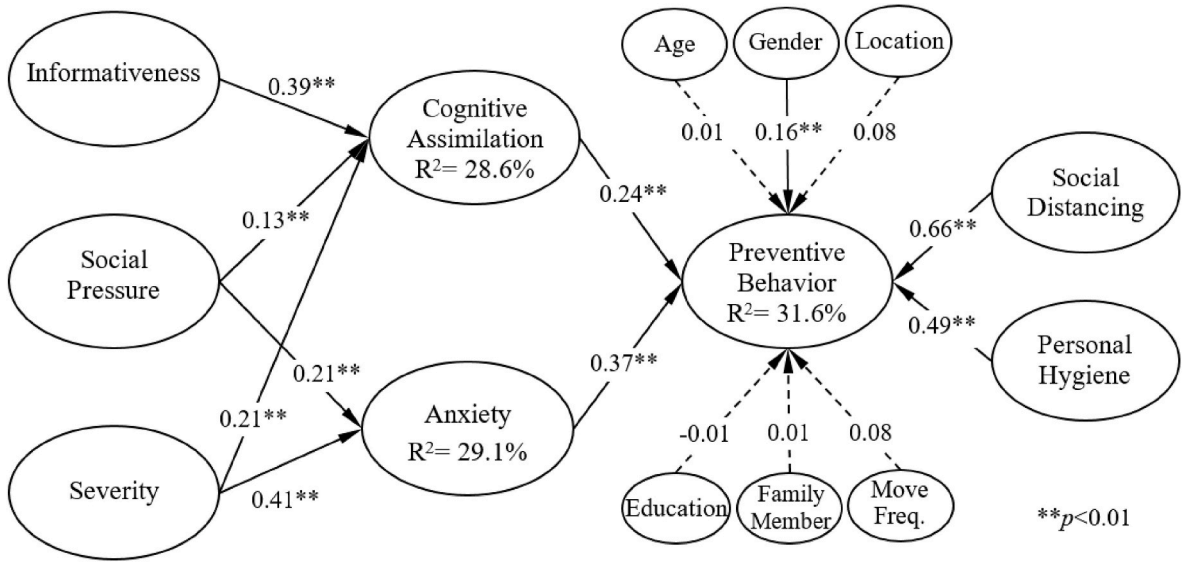


**Fig. 2.** PLS analysis results.

**Table 5**
Tests of mediating effects.

| Hypothesis Relationship | Path coefficient | Bootstrap 95% confidence interval (CI) | | | |
|---|---|---|---|---|---|
| *Direct effects* | | Percentile | | With bias corrected (BC) | |
| H1 IN – CA | 0.39 *sig* | 0.29 | 0.48 | 0.29 | 0.48 |
| H2a SP – CA | 0.13 *sig* | 0.03 | 0.23 | 0.03 | 0.23 |
| H2b SP – AN | 0.21 *sig* | 0.13 | 0.30 | 0.13 | 0.30 |
| H3a SE – CA | 0.21 *sig* | 0.11 | 0.31 | 0.11 | 0.30 |
| H3a SE – AN | 0.41 *sig* | 0.31 | 0.50 | 0.31 | 0.50 |
| H4 CA – PB | 0.13 *sig* | 0.06 | 0.19 | 0.06 | 0.19 |
| H5 AN –PB | 0.18 *sig* | 0.09 | 0.25 | 0.09 | 0.25 |
| ** IN–PB* | *0.04 n.s.* | *−0.02* | *0.11* | *−0.02* | *0.11* |
| * SP–PB | 0.51 *sig* | 0.43 | 0.57 | 0.43 | 0.57 |
| * SE–PB | 0.09 *sig* | 0.01 | 0.19 | 0.01 | 0.19 |
| ***Indirect effects*** | Point estimate | Percentile | | With bias corrected (BC) | |
| IN – CA – PB | 0.05 *sig* | 0.02 | 0.08 | 0.02 | 0.08 |
| SP – CA – PB | 0.02 *sig* | 0.00 | 0.04 | 0.00 | 0.04 |
| SP – AN – PB | 0.04 *sig* | 0.02 | 0.06 | 0.02 | 0.06 |
| SE – CA – PB | 0.03 *sig* | 0.01 | 0.05 | 0.01 | 0.05 |
| SE – AN – PB | 0.07 *sig* | 0.04 | 0.11 | 0.03 | 0.11 |
| Total indirect effect | 0.20 *sig* | 0.09 | 0.33 | 0.09 | 0.33 |

Notes. *sig*: significant; *n.s.*: not significant. *The causal relationships are not included in the proposed model.

substantively explained variance of the indicators was 0.694 and the average method-based variance was 0.01. The explained variances of all method factors were low. In addition, we also conducted a marker variable analysis (Lindell & Whitney, 2001), comparing the zero-order correlations of the research's variables with their partial correlations, after controlling for a marker variable. Because the zero-order and partial correlations are similar after controlling for the marker variable and no correlations significantly differ, the result suggested that CMVB should not be a substantive concern. Furthermore, the construct-level correction approach with the unrelated control variables was also applied for the marker variable test. The results showed that the path coefficients and explained variance values are similar to the original estimates. Finally, the results of a full collinearity analysis for evaluating CMVB showed that the variance inflation factors (VIF) of all constructs were less than the threshold value of 3.3 (Kock, 2015). Collectively, we concluded that CMVB was not a serious problem in this study.

## 6. Discussion and conclusion

Our results indicate that informativeness, social pressure, and severity directly affect cognitive assimilation. This finding demonstrates that information acquisition is a critical factor influencing individuals' assimilation of knowledge and identifying useful information. Similarly, increasing awareness of COVID-19 through trustworthy information sources can improve social distancing and personal hygiene practices (Qazi et al., 2020). In addition, informativeness exerts a stronger influence on cognitive assimilation than do social pressure and severity,

which suggests that the information from the CECC is crucial for individuals. Social pressure and severity are distinctive external pressures that influence others to follow social norms during the COVID-19 pandemic. The results of this study indicate that an individual's cognitive process is triggered by surrounding people having analogously normative behavior and the individual's awareness of the risks of contracting or spreading COVID-19. Social pressure and severity directly affect anxiety, with the corresponding influence coefficients being significant. Our finding for severity is consistent with those of other empirical studies (e.g., Song et al., 2021; Zheng et al., 2020). Moreover, social pressure not only influences the negative affective state of anxiety but also the positive cognitive state of cognitive assimilation.

Cognitive assimilation and anxiety directly affect preventive behavior, which indicates that cognitive and emotional states have critical influences on preventive behavior. Psychological changes caused by public health emergencies are directly expressed through emotions and cognition (Li et al., 2021). For example, sadness (Song et al., 2021), depression (Seçer & Ulaş, 2021), grief (Berinato, 2020), and fear (Lima et al., 2020) have been identified as critical factors influencing an individual's preventive behavior. Studies have indicated that emotional states influence various behaviors. We observed that high levels of cognitive assimilation and anxiety might lead to a high willingness to maintain health preventive behavior. This finding is in line with that of Fragkaki et al. (2021). Our empirical results provide an interesting finding regarding gender in a pandemic context. The results of PLS-SEM indicate that gender is positively associated with an individual's preventive behavior (Fig. 2). This finding is consistent with those of other studies (Algara, Fuller, Hare, & Kazemian, 2021; Hiller, Schatz, & Drexler, 2017) and indicates that women might express greater concern over public health issues than do men. Studies have observed significant gender differences in the fear of COVID-19 and adherence to social distancing (Mohammadpour et al., 2020).

The results in Table 5 indicate that cognitive assimilation exerts full mediating effects on the relationship between informativeness and an individual's preventive behavior (i.e. social distancing and personal hygiene). Thus, the CECC has played a critical role in the disclosure of reliable, helpful, and easy-to-understand information during the COVID-19 pandemic. The Taiwanese government has corrected misinformation and fake news and created new laws to prohibit the spread of misinformation. Therefore, an individual can easily acquire accurate information, which can help them adjust to new thoughts and the CECC's recommended actions to prevent COVID-19. This finding is consistent with those of other studies (e.g., Barreda-Ángeles & Hartmann, 2022; Qazi et al., 2020; Song et al., 2021; Wang et al., 2022), which have revealed that the development of situational awareness during public health crises based on formal information sources facilitates the adoption of appropriate preventive behavior, which can limit the spread of infectious diseases.

### 6.1. Theoretical implications

Our findings have three critical theoretical contributions. First, our findings indicate how contextual factors influence an individual's cognitive and emotional states, which in turn influence their preventive behavior. Digital and physical stimuli from an external environment affect an individual's psychological factors, which in turn influence their willingness to engage in preventive behavior. The results of our findings are consistent with the prior research (e.g., Barreda-Ángeles & Hartmann, 2022; Beaudoin & Hong, 2021; Peng, 2022) and offer insight from an informational-contextual perspective and a social digital and physical stimulus perspective and suggest that informativeness, severity, and social pressure are key stimuli that strongly affect an individual's psychological state during the COVID-19 crisis. Severity and social pressure also strongly influence an individual's emotional state. Second, our findings indicate that cognitive assimilation and anxiety are key drivers of an individual's preventive behavior. The results of this study indicate that anxiety has a stronger influence on an individual's behavior than does than cognitive assimilation. This finding elucidates the organism's effect on responses within the S–O–R model. Theoretical studies have indicated that emotional states (e.g., sadness, depression, grief, and fear) significantly influence an individual's behavior (e.g., preventive behavior and information avoidance behavior). We discovered empirical evidence that indicates that emotional states exert considerably stronger effects on individuals' preventive behavior than do cognitive states. Third, the results of this study indicate that cognitive assimilation exerts a full mediating effect on the relationship between informativeness and preventive behavior (personal hygiene and social distancing). In summary, the findings provide detailed insight into causality within the S–O–R model and indicate that informativeness, social pressure, and severity influence cognitive assimilation and anxiety, which in turn affect an individual's preventive behavior.

### 6.2. Practical implications

Our results have several practical implications for COVID-19 prevention. An individual's engagement in preventive behavior is a central focus of public health policies implemented to mitigate the spread of COVID-19, and promoting behavioral changes is crucial for preventing COVID-19 transmission in the absence of pharmaceutical interventions (Chen, Min, et al., 2020; Soofi, Najafi, & Karami-Matin, 2020; West, Michie, Rubin, & Amlôt, 2020). Many governments have implemented measures such as quarantine, isolation, and social distancing to control the COVID-19 pandemic. In addition to these measures, people should adopt certain effective behaviors, such as maintaining personal hygiene, to protect themselves and others. Moreover, governments should provide the public with easily accessible, reliable, accurate, and up-to-date information, such as the locations of confirmed cases and transmission chain relationships, at a fixed time daily to address the psychological effects of the COVID-19 pandemic. Public confidence in the information released by government agencies might strengthen the public's information processing, which leads to cognitive assimilation. By contrast, public confusion about the reliability of the provided information might lead to sustained anxiety. Thus, government agencies should minimize the public's confusion regarding preventive behavior. Practices such as daily press conferences, clear digital platform labelling, and more effective use of social media to disperse accurate crisis-related information can be implemented to establish a transparent and professional media communication flow for sharing pandemic-related data, providing information on the latest government policies, and correcting false information. The results of this study indicate that cognitive assimilation and anxiety have partial mediating effects on the relationships of social pressure and severity with an individual's preventive behavior. Community and government leaders should provide clear and easily accessible guidance on how to best follow the established preventive measures to reduce the spread of COVID-19 because such guidance might reduce anxiety or increase cognitive assimilation among the population. Governments should implement mental health programs during pandemics to explain to the public the reasons for feelings of anxiety and how to reduce the anxiety experienced in a situation, especially when the number of infections increases.

### 6.3. Limitations and future study

This study has limitations that should be considered when the results are interpreted. First, the empirical data were collected from a popular Taiwanese survey website, and all the respondents were from Taiwan. Thus, caution should be applied when generalizing the empirical results to other countries because the political, economic, social, technological, and even cultural context of our setting or different periods might play an influential role. Second, this study had a cross-sectional design. Because of time and resource constraints, data could not be collected to examine respondents' feelings and states at different times; thus, long-

term changes in the examined factors could not be investigated. Third, some nonresponse bias might have affected the empirical results of this study even though a nationally representative research sample was adopted, a wide range of cognitive and emotional factors were examined, and a well-validated comprehensive assessment of preventive behavior against COVID-19 was conducted. Studies can conduct cross-cultural research to examine how COVID-19 control policies influence individuals' preventive behaviors in different countries. Finally, because COVID-19 is an ongoing phenomenon, we validated the identified constructs, examined their influences, and determined the significance levels of these influences only in an exploratory context. To control communicable diseases, the sub-goal of SDG 3 examined in this study, namely the sub-goal related to personal hygiene (in this study, personal hygiene included washing hands, wearing a mask, and covering the mouth and nose when sneezing or coughing), should be expanded to include personal health promotion, including the promotion of a healthy diet, moderate exercise, adequate sleep, ecological conservation, and closeness to nature.

## 7. Conclusion

This study found that based on the theoretical perspectives of S–O–R model, three digital and physical stimuli, namely informativeness, severity, and social pressure positively affect an individual's cognitive and psychological states, namely cognitive assimilation and anxiety, which in turn positively influence an individual's preventive behavior against COVID-19 transmission. The preventive behavior can be theorized as a higher-order construct comprising of social distancing and personal hygiene. Overall, our research results represent an attempt to extend our collective understanding of the mechanisms by which the three digital and physical factors individually and jointly influence an individual's cognitive and psychological states and drive an individual's preventive behavior against COVID-19 transmission. Among the three stimuli, informativeness exerts a stronger influence on cognitive assimilation than do social pressure and severity, which suggests that accurate government information is crucial for individuals.

## Declaration of competing interest

None of the authors have a conflict of interest with this research.

## Data availability

Data will be made available on request.

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## Appendix A. Measurement items and the related literature

| Construct | Item | Scales | Literature/Items developed from |
|---|---|---|---|
| Informative-ness (IN) | IN1 | I think the epidemic information from the CECC is timely (such as releasing the latest information at a daily fixed time). | Abbasi et al. (2021); Lee et al. (2022); Moldovan et al. (2019); Nasir et al. (2021); Roux and Maree (2021) |
| | IN2 | I think the epidemic information from the CECC is understandable. | |
| | IN3 | I think the contact tracing information from the CECC is thorough (such as footprints of confirmed cases and transmission chain relationships) | |
| | IN4 | I think the contact tracing information from the CECC is reliable. | |
| | IN5 | I think the prevention information from the CECC is helpful. | |
| Social pressure (SP) | SP1 | Based on the cyber-physical stimuli around me I think it is important that I should reduce face-to-face contact. | Ajzen (2005; 2020); Aylie et al. (2020); Bronfman et al. (2021); Hagger and Hamilton (2022); Salari et al. (2020) |
| | SP2 | Based on the cyber-physical stimuli around me I think it is important that I should reduce going out. | |
| | SP3 | Based on the cyber-physical stimuli around me I think it is important that I should follow the preventive rules | |
| Severity (SE) | SE1 | I think the COVID-19 epidemic is severe. | Fragkaki et al. (2021); Li et al. (2021); Seçer and Ulaş (2021) |
| | SE2 | I think COVID-19 can be life-threatening. | |
| | SE3 | I think the infectiousness of COVID-19 is serious. | |
| Anxiety (AN) | AN1 | I feel it is difficult to relax during the COVID-19 epidemic. | Ayittey et al. (2020); Bao et al. (2020); Mongkhon et al. (2021); Salari et al. (2020); Shah et al. (2021) |
| | AN2 | I feel uneasy about my life and work during the COVID-19 epidemic. | |
| | AN3 | I feel anxious about emerging coronavirus variants (such as the Delta variant). | |
| | AN4 | I am worried about myself or my family being infected with COVID-19. | |
| Cognitive assimilation (CA) | CA1 | My thoughts on the epidemic can be influenced by public health information on epidemic prevention. | Algara et al. (2021); Fragkaki et al. (2021); Li et al. (2021); Qazi et al. (2020); Song et al. (2021) |
| | CA2 | My thoughts of the epidemic can be influenced by understanding new information from the CECC. | |
| | CA3 | My thoughts of the epidemic can be adjusted by experts' experiences (such as doctors). | |
| Social distancing (SD) | SD1 | I may reduce unnecessary contact with others. | Andrasfay et al. (2022); Bronfman et al. (2021); Coroiu et al. (2020); Pearce (2020) |
| | SD2 | I may reduce my participation in social events (such as parties and gatherings). | |
| | SD3 | I may reduce using public transport. | |
| Personal hygiene (PH) | PH1 | I wear a mask in the street and closed places (such as supermarkets, pharmacies) | Bronfman et al. (2021); Chen, Ran, et al. (2020); Li et al. (2021) |
| | PH2 | I wash my hands when I get home with sanitizer or soap. | |
| | PH3 | I cover my mouth and nose when I sneeze or cough. | |

## Appendix B. Item loadings and cross-loadings

| Construct | Item | IN | SP | SE | CA | AN | SD | PH |
|---|---|---|---|---|---|---|---|---|
| Informative-ness (IN) | IN1 | **0.797** | 0.188 | 0.107 | 0.324 | 0.025 | 0.130 | 0.201 |
| | IN2 | **0.842** | 0.221 | 0.176 | 0.371 | 0.090 | 0.174 | 0.226 |
| | IN3 | **0.840** | 0.179 | 0.096 | 0.334 | 0.075 | 0.168 | 0.161 |
| | IN4 | **0.863** | 0.200 | 0.097 | 0.348 | 0.058 | 0.142 | 0.171 |
| | IN5 | **0.848** | 0.256 | 0.205 | 0.483 | 0.186 | 0.235 | 0.269 |
| Social pressure (SP) | SP1 | 0.194 | **0.813** | 0.373 | 0.277 | 0.290 | 0.475 | 0.344 |
| | SP2 | 0.149 | **0.851** | 0.352 | 0.221 | 0.346 | 0.514 | 0.347 |
| | SP3 | 0.268 | **0.798** | 0.407 | 0.295 | 0.345 | 0.537 | 0.559 |
| Severity (SE) | SE1 | 0.113 | 0.353 | **0.767** | 0.244 | 0.373 | 0.304 | 0.246 |
| | SE2 | 0.160 | 0.380 | **0.869** | 0.279 | 0.420 | 0.313 | 0.345 |
| | SE3 | 0.154 | 0.433 | **0.891** | 0.315 | 0.478 | 0.374 | 0.420 |
| Cognitive assimilation (CA) | CA1 | 0.373 | 0.273 | 0.247 | **0.829** | 0.256 | 0.293 | 0.290 |
| | CA2 | 0.436 | 0.289 | 0.306 | **0.849** | 0.351 | 0.322 | 0.271 |
| | CA3 | 0.266 | 0.215 | 0.247 | **0.731** | 0.264 | 0.238 | 0.256 |
| Anxiety (AN) | AN1 | 0.083 | 0.364 | 0.447 | 0.292 | **0.836** | 0.352 | 0.331 |
| | AN2 | 0.089 | 0.285 | 0.387 | 0.283 | **0.865** | 0.366 | 0.268 |
| | AN3 | 0.079 | 0.316 | 0.401 | 0.304 | **0.848** | 0.396 | 0.272 |
| | AN4 | 0.124 | 0.362 | 0.444 | 0.330 | **0.789** | 0.371 | 0.324 |
| Social distancing (SD) | SD1 | 0.199 | 0.569 | 0.345 | 0.355 | 0.398 | **0.894** | 0.474 |
| | SD2 | 0.196 | 0.538 | 0.348 | 0.314 | 0.419 | **0.891** | 0.450 |
| | SD3 | 0.124 | 0.462 | 0.300 | 0.221 | 0.300 | **0.732** | 0.352 |
| Personal hygiene (PH) | PH1 | 0.208 | 0.468 | 0.398 | 0.289 | 0.310 | 0.448 | **0.824** |
| | PH2 | 0.228 | 0.416 | 0.327 | 0.272 | 0.334 | 0.404 | **0.803** |
| | PH3 | 0.180 | 0.389 | 0.267 | 0.266 | 0.240 | 0.392 | **0.823** |

Note. All items loaded significantly ($p < .01$) on their respective constructs. Bold values signify the items that loaded highest on the factor.

## Appendix C. Common method bias analysis

| Construct | Item | Substantive factor loading (R1) | $R1^2$ | Method factor loading (R2) | $R2^2$ |
|---|---|---|---|---|---|
| Informative-ness (IN) | IN1 | 0.835** | 0.697 | −0.051 | 0.003 |
| | IN2 | 0.833** | 0.694 | 0.021 | 0.000 |
| | IN3 | 0.878** | 0.771 | −0.051 | 0.003 |
| | IN4 | 0.906** | 0.821 | −0.062 | 0.004* |
| | IN5 | 0.743** | 0.552 | 0.144 | 0.021** |
| Social pressure (SP) | SP1 | 0.882** | 0.778 | −0.077 | 0.006* |
| | SP2 | 0.956** | 0.914 | −0.127 | 0.016** |
| | SP3 | 0.622** | 0.387 | 0.209 | 0.044** |
| Severity (SE) | SE1 | 0.808** | 0.653 | −0.049 | 0.002 |
| | SE2 | 0.892** | 0.796 | −0.030 | 0.001 |
| | SE3 | 0.833** | 0.694 | 0.072 | 0.005* |
| Cognitive assimilation (CA) | CA1 | 0.938** | 0.880 | −0.088 | 0.008** |
| | CA2 | 0.876** | 0.767 | −0.033 | 0.001 |
| | CA3 | 0.693** | 0.480 | 0.114 | 0.013* |
| Anxiety (AN) | AN1 | 0.846** | 0.716 | −0.026 | 0.001 |
| | AN2 | 0.778** | 0.605 | 0.080 | 0.006* |
| | AN3 | 0.795** | 0.632 | −0.062 | 0.004 |
| | AN4 | 0.824** | 0.679 | 0.018 | 0.000 |
| Social distancing (SD) | SD1 | 0.865** | 0.748 | 0.037 | 0.001 |
| | SD2 | 0.882** | 0.778 | 0.010 | 0.000 |
| | SD3 | 0.779** | 0.607 | −0.057 | 0.003 |
| Personal hygiene (PH) | PH1 | 0.771** | 0.594 | 0.070 | 0.005 |
| | PH2 | 0.778** | 0.605 | 0.037 | 0.001 |
| | PH3 | 0.901** | 0.812 | −0.107 | 0.011** |
| Average | | 0.830** | 0.694 | 0.000 | 0.007 |

Note. *$p < .05$; **$p < .01$.

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