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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Commentary

Looking Beyond Cognition for Risky Decision Making: COVID-19, the Environment, and Behavior

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Successful management of a pandemic depends on human behavior. Vaccine development and availability of personal protective equipment such as facial coverings are of little benefit if people do not use them. Thus, a key defense against a spreading disease is large-scale adherence to behavioral mitigation practices, such as the CDC's recommended preventive behaviors and vaccination. The COVID-19 pandemic has revealed the difficulty in activating this defense. Reyna et al. (2021) compare three types of cognitive theories–expectancy value, dual process, and fuzzy trace–explaining the role of information and memory in risky decision making, focusing on how these constructs apply to COVID-19. While Reyna et al. outline the differences among these three types of theories, noting the evidence in favor of Fuzzy Trace Theory, we point out what all three theories have in common: They focus solely on cognition. A proper understanding of cognition is of fundamental importance for predicting and explaining behavior, but forces beyond cognition also drive decision making. We focus on two such factors.

First, cognition works in concert with the environment (Brunswik, 1952). Herb Simon likened human behavior to a pair of scissors whereby one blade–cognition–works together with the second blade–the environment–to determine the behavior (Simon, 1990). Thus, risk perceptions and preventive behavior during the COVID-19 pandemic are driven by an interaction between internal cognitive mechanisms and the structure of information in the external world. Risk perceptions are not formed in a vacuum but are shaped by the environments in which hazards occur. Theories that merge models of decision environments with cognition can more fully explain the variability in beliefs and perceptions of COVID-19. Leveraging cognitive-ecological theory, we outline how an understanding of the information ecology sheds light on misaligned risk perceptions.

Second, changing beliefs and cognition does not always translate into changed behavior. Providing accurate information with a memorable gist may change risk perception, but changes in risk perception do not always result in changes in behavior. Preferences and behavioral responses may be constructed at the moment (Payne et al., 1999), and this construction makes use of environmental cues (McKenzie et al., 2018). Behaviors that are convenient, easy to execute, and cued by the context are more likely to be selected. Consequently, adherence to behavioral mitigation strategies may require interventions that target behavior directly, bypassing risk perceptions and cognition, using, for example, reminders, defaults, incentives, and requirements.

In the following, we first discuss theories that integrate risk perception with the dynamics of the COVID-19 environment. We outline sources of inaccurate and accurate risk perceptions and make recommendations for improving their accuracy. Facilitating accurate risk perceptions is important even if it does not result in changes in behavior because it makes the decision maker more informed and may promote trust in official sources of risk information. Second, we discuss theories of behavioral change, examining the role of nudges and other behavioral interventions for mitigating COVID-19. We discuss the contexts and populations where such direct behavioral interventions are most likely to work.

Environmental Influences on COVID-19 Risk Perception

How do people form risk perceptions of global and complex risks such as pandemics? Foundational work on the psychology of perception has demonstrated that "certain objects function as the local representatives of others by serving as cues for the others" (Tolman & Brunswik, 1935). Brunswik (1952) formalized these ideas into a lens model which has also been fruitfully applied to the study of judgment (Broomell & Budescu, 2009; Hammond et al., 1966; Kane & Broomell, 2020; Karelaia &

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Hogarth, 2008). Within the lens model framework is Brunswik's notion of probabilistic functionalism–that humans rely on multiple cues to reinforce perceptions of distal objects–which suggests that understanding how people perceive complex risks such as COVID-19 requires understanding all of the cues the public may use to form their perceptions.

Some cues come from information sources that can be mentally encoded as verbatim or gist information and later recalled at the time of decision making, while other cues are present in the immediate decision-making environment and therefore need not be recalled. Exposure to information sources happens periodically, and memory for the information can decay over time (especially verbatim information). In contrast, perceptions of the environment occur continuously through time and can reinforce or contradict the remembered information sources. If perceptions of the environment conflict with recalled information sources, these perceptions may erode the impact of the information source. This effect has been observed for perceptions of rare events in research examining the role of experiences in decision making (Hertwig & Erev, 2009; Jessup et al., 2008). For example, in an interview conducted by Carey (2020), Ido Erev describes his own personal observations of how, during the second intifada, Israeli citizens sheltered due to reports of danger, but over time, their daily experiences led them to begin to resume normal life again despite there being no change in the danger of the situation.

Although our perceptual systems are adapted to take advantage of many environmental contexts (Simon, 1990), some environments can work against our perceptual mechanisms, creating inaccuracies, biases, and polarization (Arkes, 1991; Broomell, 2020a; Fiedler, 2000; Hogarth et al., 2015). Indeed, Fiedler (2000) discusses how decision biases associated with probabilistic judgment can be explained by biases in small samples of instances observed from the environment. It is impossible to directly observe the entire COVID-19 pandemic from any given local environment; consequently, people may still rely on locally observable cues to inform their risk perceptions.

When the cues that serve as local representatives fail to accurately reflect their global counterpart, the global risk and the local environment are said to be incompatible (Broomell, 2020b). There are many ways in which local environments can become incompatible with global risks, even when perceptions are based on ecologically valid cues. Global-local incompatibility theorizes that the natural distribution of cues across local environments can make them appear stable and reliable while simultaneously masking our perception of global risks (Broomell, 2020a). This creates a disconnect between the stability in what we see and changes in our personal risk that are slowly happening. Even worse, when the local environments of a population of people differ due to random fluctuations, then at any given time, different subpopulations will have different perceptions of risk leading to inaccurate risk perceptions across a population (Kane & Broomell, 2020). Assuming that a localized perception of risk facilitates sustained risk mitigation action, heterogeneity in risk perceptions can hinder a society's ability to mitigate risk when benefits can only be obtained from vigilant collective action, such as the benefits of masking, social distancing, and vaccination.

In the context of the COVID-19 pandemic, global-local incompatibility can help explain why, despite more than half a million people in the U.S. dying from COVID-19 in a single year, public risk perceptions of infection and mortality remain variable and highly polarized. Broomell and Kane (2021) identified the superspreading associated with SARS-CoV-2 (the virus that causes the disease COVID-19) as a large source of variability in this context. Using a combination of epidemiological modeling and global-local incompatibility, Broomell and Kane demonstrate how superspreading diseases create a large variance in infections across geographic localities and how this variance can be linked to judgments to explain highly variable, polarized, and inaccurate risk perceptions. The distribution of COVID-19 cases was highly skewed, such that most people had a very small probability of seeing an outbreak. Indeed, at the start of the pandemic in the U.S., most people were in local environments where the disease burden was very low while a minority of people were in local environments where the burden was very high. Therefore, while COVID-19 infected many people on the global scale, early in the pandemic most localities (such as U.S. counties) did not experience an outbreak and did not have any local signals of risk. However, a lack of local outbreak does not imply safety from the pandemic, analogous to the Ido Erev example above. In fact, inaccurate risk perceptions based on local cues could make matters worse if they lead to complacency, because as infection clusters move from location to location, they can more easily take hold in locations with lower adherence to mitigation actions, with superspreading infecting many people all at once, before any local indication of an outbreak could be observed.

This theoretical framework suggests several possible pathways to tailor information sources to be maximally effective while considering both cognitive and environmental factors. First, focusing attention on locally observable cues that are stable across local environments should reduce possible conflicts between information sources and perceptions. While there is no guarantee that such cues exist, if they do, finding them and designing messaging that focuses on them could help reduce heterogeneity in risk perceptions. Second, communicators might directly address why people are still at risk even when they do not see any local infections. For many, a lack of local infections might suggest that behavioral mitigation measures are not needed. Communications might focus on how such mitigation behaviors are needed even more in this circumstance because the population has not yet been infected, and, much like a powder keg, the smallest spark would be catastrophic. Finally, having local representatives generate messages within local environments (in conjunction with centralized national or federal representatives) could maximize the degree to which communications resonate with consumers even if they have different local contexts. Trusted local information sources can remove the uncertainty about whether information applies to a given individual's circumstance.

Risk perceptions of COVID-19 are just one example of a broader set of tensions between cognition and the environment

(see Broomell, 2020a; Broomell et al., 2020). It might seem reasonable to assume that if a hazard was severe, that regardless of the local information available, everyone would come to recognize the hazard. However, such consensus recognition has failed to happen for climate change despite overwhelming evidence (Weber, 2006). In the case of climate change, the lack of consensus might be attributed to the long time horizons and related cognitive phenomena (such as time discounting, myopic bias, etc.). However, the research reviewed here suggests that it is easy to disagree even on risks such as pandemics that arise, spread, and lead to millions of deaths within the span of one or two years. Properties of the decision environment allow us to understand when and why this might happen.

Direct Intervention on Behavior

Expectancy-value theories, as reviewed by Reyna et al. (2021) posit that decisions are based on the combination of beliefs and values. That is, decision makers appraise how likely and how good or bad relevant outcomes would be and choose the course of action with the best expected outcome. For example, the decision to vaccinate would be based on beliefs about the risks of the disease and the effectiveness of the vaccine, and the values of being healthy versus getting sick. According to this traditional framework, interventions to encourage vaccine uptake would focus on modifying beliefs and values. For example, interventions might include information campaigns to correct inaccurate beliefs about the likelihood of infection, the severity of outcomes if one does become infected, and the efficacy of the vaccine in reducing those risks. If such campaigns were successful in changing beliefs, vaccination behavior would come in line with the new beliefs. Likewise, interventions that change values–such as fear appeals to augment the negative value of getting infected–would alter the decision, according to the expectancy-value framework. Reyna et al. outline the limitations of expectancy-value theory, but the alternative theories they present (dual-process theory and fuzzy trace theory) also focus on cognition. In the context of a pandemic, it is relevant to examine whether changes to cognitions, such as risk perceptions, result in behavior change.

Engaging in preventive behaviors is strongly correlated with self reports of risk perceptions and other beliefs. For example, a survey of a US nationally representative sample early in the pandemic (Broomell et al., 2020) found that self reported social distancing, respiratory hygiene, and mask wearing behaviors were strongly associated with the perceived effectiveness of these behaviors and modestly correlated with fear of spreading or catching the disease. Risk appraisals of perceived likelihood and perceived severity of a disease are reliably correlated with vaccination behavior (Brewer et al., 2007). A large literature (e.g., Schmid et al., 2017) demonstrates that vaccination behavior is strongly associated with vaccine confidence, measured as the belief that vaccines are safe and effective and trust in the system that develops and distributes vaccines. Despite this strong correlational data, however, evidence on the causal link between beliefs and preventive health behavior is more mixed.

One reason behavior change may not result from interventions designed to change beliefs is that the intervention does not actually change beliefs. A second reason is that the changed beliefs do not translate into behavior. A meta-analysis (Sheeran et al., 2014) identified 93 studies with an intervention that successfully heightened risk appraisal and an assessment of behavior (not just intention). A variety of behaviors (e.g., smoking, sun protection) was assessed in this group of studies. Among these studies, the interventions had a modest effect on behavior ($d = 0.23$). A meta analysis of fear appeals (Tannenbaum et al., 2015) in 127 papers found a modest average effect of fear messaging on attitudes, intentions, and behavior ($d = 0.29$), with large heterogeneity. Thus, changes in risk perceptions and risk-relevant emotions can produce modest behavioral changes; however, such interventions are sometimes ineffective or can even backfire. An online experiment with parent participants found that providing information about vaccine efficacy and safety can, in some circumstances, backfire and decrease vaccine confidence or vaccination intention (Nyhan et al., 2014). A similar effect was also demonstrated in Betsch and Sachse (2013) who found that strong messages about vaccine safety backfire. That is, strong messages that vaccines have no risk lead to higher perceived risk than weaker negations if the messages come from an untrusted source (a pharmaceutical company). Thus, messages designed to change vaccine risk appraisals can have mixed or unexpected results.

The study of the cognitive and environmental underpinnings of risk perceptions is motivated in part by the assumption that risk perceptions are causally related to risk-reducing behavior. Understanding how risk perceptions are formed should guide efforts to correct risk misperceptions and thereby encourage warranted risk-reduction behavior such as vaccination. Understanding and correcting risk perceptions is important in its own right as individuals who have accurate risk perceptions are more informed decision makers, and transparent and effective risk messaging can build trust in the message source. However, Brewer et al. (2017) conclude that "thoughts and feelings are not currently a reliable basis for interventions to increase vaccination" (p. 166). Given that interventions to change risk appraisals have a mixed track record of influencing behavior, behavioral change may be most effective through interventions that target behavior directly, bypassing risk perception (Brewer et al., 2017).

Messaging about vaccination may be effective not because it alters risk appraisal but via other psychological mechanisms. Dai et al. (2021) sent COVID vaccination text message reminders to individuals who had just become eligible for the vaccine. Compared to no reminder, a text reminder boosted vaccination rate by 3.5 percentage points, demonstrating the influence of simple reminders (Jacobson Vann & Szilagyi, 2018). Further, messages that were designed to make recipients feel ownership for the vaccine were more effective, increasing vaccination by about 1 percentage point compared to messages that lacked this feature (see also Milkman et al., 2021; Buttenheim et al., 2021). The purported mechanism underlying the effects of ownership messaging is the endowment effect (objects one owns are more valuable than identical objects one does not own) and reciprocity (if the clinic has reserved

a vaccine dose for me, I should reciprocate and accept the dose), not changes in risk perception.

Another example of direct intervention on behavior, bypassing risk appraisals, is default scheduling of vaccine appointments. In two studies (Chapman et al., 2010, 2016), individuals were either told that they could make a flu shot appointment (opt-in condition) or that an appointment had already been scheduled for them, which they could cancel or change if desired (opt-out condition). In-clinic vaccination, rates were 11 to 12 percentage points higher in the opt-out condition compared to the opt-in or no-message conditions. The automatically scheduled appointment likely created a situation where attending the appointment became the path of least resistance.

Provider recommendations are strongly associated with vaccination behavior (Opel et al., 2015), and they may act via multiple mechanisms, including potentially increasing perceptions of the likelihood and severity of the infectious disease. A randomized experiment (Brewer et al., 2017) demonstrated that presumptive announcements that a child is due for vaccination results in higher HPV vaccination uptake compared to participatory conversations. Presumptive announcements likely harness injunctive social norms and convey a standard practice default.

Whereas reminders and default appointments are likely influential primarily among people who have positive attitudes toward vaccination, other strategies may be needed among those who do not. Some experiments have demonstrated that incentives increase vaccination uptake (e.g., Banerjee et al., 2010). Incentives provide an external reward that increases the value of getting vaccinated without changing the value of the vaccination itself. A stronger inducement for vaccination is a requirement or mandate. Many countries and states have vaccination requirements for school entry, and in 2021, many US employees issued mandates for employees to receive a COVID-19 vaccine. Evidence indicates that mandates do work; for example, jurisdictions that allow religious or philosophical exemptions have lower vaccination rates than those that do not allow such exemptions (Omer et al., 2006).

Research on risk perception and risky behavior has multiple goals. One goal is to understand the basic cognitive mechanisms underlying risk perceptions and the reasons why risk perceptions sometimes deviate from the actual frequency of the hazard event. Another goal is to understand the mechanisms underlying the risky behavior and to develop and test techniques for changing risky behavior. When the second goal is prominent, evidence indicates that looking beyond risk perception as a lever for changing behavior is warranted.

Conclusion

Theories of cognition are essential for understanding the basic processes underlying encoding and memory of public health messages. Such theories have downstream implications for behavior because a message that is not remembered is unlikely to influence later behavior. Consequently, as argued by Reyna et al. (2021), messages that convey an accurate gist will have a longer standing effect than those that do not. As we argue in the current paper, however, when it comes to facilitating preventive behavior during a pandemic, targeting cognition is only part of the picture because risk perceptions and risk-reducing behaviors are multiply determined. In addition to memory for messages previously received, the cues and information ecology in the immediate environment also affect risk perception. Furthermore, evidence is mixed as to the causal link between risk perception and behaviors such as vaccination whereas there is robust evidence for intervening on behavior directly through reminders, defaults, incentives, and requirements.

We reviewed theories and evidence that expand beyond cognition, attempting to explain the role of social and natural environments in shaping our risk perceptions and behavioral responses to the COVID-19 pandemic. Calibrating risk perceptions can lead to a more informed public, increase public oversight and trust in institutions, and potentially lead to positive health outcomes at community and national levels. Focusing on behavior can open doors to interventions that may effectively elicit mitigation behavior from populations of people with heterogeneous risk perceptions who share the same risks. Activating human behaviors that can effectively address the COVID-19 pandemic, therefore, requires a multi-faceted approach, harnessing social science research on the many drivers of behavior.

Author Contributions

Both authors wrote the manuscript.

Conflict of Interest

The authors declare that they have no conflict of interest.

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