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Journal of Applied Research in Memory and Cognition

journal homepage: www.elsevier.com/locate/jarmac

Commentary

Fuzzy-Trace Theory and the Battle for the Gist in the Public Mind



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Keywords: Fuzzy-Trace Theory, Gist representations of vaccination and COVID-19, Contested gist, Misinformation about vaccination and COVID-19, Framing and gist of health information

The anti-vaccination movement has gone mainstream. Although there have been vaccine skeptics for as long as there have been vaccines, the contemporary movement got a push by the discredited ex-doctor Andrew Wakefield (Hussain, Ali, Ahmed, & Hussain, 2019), and by the fall of 2021, over one-third of Americans had still not received a single dose of a COVID-19 vaccine despite widespread and free availability (Mayo Clinic, 2021). Today we have reached the point where political commentators, professional “trolls” from other countries, and social media influencers routinely spread misinformation about COVID-19 and vaccines of all kinds (Fetters & De Vynck, 2021). Even among the vaccinated, a sizable minority is coming to view vaccine refusal as a “civil right” (Broniatowski et al., 2020), repurposing the slogan “my body my choice.” Lawmakers in some U.S. states have moved to block local government and school mandates requiring vaccination and facemasks. Indeed, one wonders how long it will be until politicians begin objecting to the use of tax dollars for vaccine research and inoculating the public. Given the current crisis and impasse, the time is ripe for Reyna et al.’s (2021) discussion of Fuzzy-Trace Theory and the “battle for the gist in the public mind.”

Fuzzy-Trace Theory: The View from 35,000 Feet

Psychologists know a good deal about “associations.” The association between stimulus and response is, of course, at the heart of classical conditioning. But associations are understood and leveraged by cognitive scientists in more sophisticated ways. For example, latent higher-order associations among words are at the heart of Latent Semantic Analysis (LSA) and its mathematical cousins (Landauer, Foltz, & Laham, 1998). Marching under the banner, “words derive their meaning from the company they keep” (Graesser, McNamara, & Kulikowich, 2011), LSA not only assigns high semantic

similarity values to words that are often used in the same sentence, for example, “peanut butter” and “jelly” but also to words such as “peanut butter” and “bologna” that rarely show up in the same sentence, but are latently related through the company of other shared word associations such as sandwich, lunch, juice box, and so on. Indeed, associations are so well understood that many psychologists assume that associations are the “alpha and omega” of human cognition. It is in this context that Reyna and colleagues make a persuasive case for *meaning* over and above mere association as a lynchpin of human cognition (Reyna, 2008, 2012, 2021; Reyna & Brainerd, 1995).

Meaning is central to Fuzzy-Trace Theory, but the theory does not require us to “hop into the hermeneutic circle” or abandon scientific principles. Fuzzy-Trace Theory is not concerned with grand philosophical questions. Rather, it addresses the persistent problems of cognitive science involving basic mechanisms, cognitive processes, and the interplay between mental representation, information processing, and action. A key insight of Fuzzy-Trace Theory is that there is redundancy built into the cognitive architecture. Information is encoded with multiple representations along a continuum from precise yet superficial verbatim details to vague impressions expressing the bottom-line meaning—the gist. The gist is not derived from verbatim representations, and verbatim and gist representations are independent of one another. Thus, it is possible to have precise facts available in memory without using them in processes of judgment, decision making, or reasoning.

The finding that gist representations are formed at the time of encoding corresponds to the notion of “effort after meaning” (Graesser, Singer, & Trabasso, 1994) but extends beyond language to include non-verbal experiences. I would argue that one ramification of Fuzzy-Trace Theory is that words derive their meaning from active meaning-making and also associations with non-verbal experiences, as well as associations with other words. The “traces” of Fuzzy-Trace Theory are memory traces, and contrary to what some might call common sense, evidence suggests that adults are more reliant on gist than

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children, and experts rely more on gist representations than novices (Reyna, 2012). However, “verbatim bad, gist good” would be a poor gist understanding of Fuzzy-Trace Theory. People exhibit a fuzzy processing preference to process the most gist-like representation permissible for a given task. Yet, in making good decisions, it is not enough to form a gist representation. Much of the “action” lies in developing gist representations that are accurate in capturing critical features of experience and useful in guiding decisions and action. Thus, a key to successful judgment and decision making is often developing the right gist representation. Fuzzy-Trace Theory has implications for phenomena as diverse as medical decision-making (Reyna, 2008), false memory (Reyna, Corbin, Weldon, & Brainerd, 2016), and learning (Wolfe, Reyna, & Brainerd, 2005).

The evidence for Fuzzy-Trace Theory has been reviewed elsewhere (e.g., Reyna, 2012; Setton, Wilhelms, Weldon, Chick, & Reyna, 2014), including the efficacy of health interventions based on the theory (see Blalock & Reyna, 2016). However, support for many of the major tenants of Fuzzy-Trace Theory has been “hiding in plain sight” in the classic journal literature. Contemporary researchers are generally persuaded by Cowan (2000) that four is a better number for short term memory capacity than George Miller’s (1956) magical number seven—but the *chunk* is still the agreed upon fundamental unit of measurement for short term memory, rather than the objective “bits” of information theory. Although the chunk and chunking have been defined in a variety of ways, they are generally conceived of as compiled *meaningful* units of information. Thus, although meaning often takes a back seat in basic research and theorizing about memory, it is difficult to deny the centrality of extracting meaning at the time of encoding.

The notion that bottom-line meaning is formed during encoding is even more clear in the classic literature on comprehension and recall. Early studies by Bransford & Johnson, 1972 and Bransford and Franks (1971) demonstrated that interventions at the time of encoding rather than retrieval are the drivers of performance. Classic framing effects (see Kahneman, 2003) can also be understood through the lens of Fuzzy-Trace Theory, and judgment and decision-making effects hypothesized by other theories as being dependent on specific numbers have been replicated in studies using only verbal labels such as “a majority” and “a very small minority” (Gamliel & Kreiner, 2020). The “quick and dirty” characterization of meaning-making and gist is akin to evidence-based ideas about judgment and decision making dating back to the beginning of the heuristics and biases era (e.g., Tversky & Kahneman, 1974). Thus, Fuzzy-Trace Theory stands out in several important ways but also shares many insights with well-established theories and long-standing empirical findings in cognitive psychology. Indeed, it is not unreasonable to see the roots of the Fuzzy-Trace Theory in seminal literature on comprehension, memory, development, and judgment and decision making.

Different people can derive different gist representations from the same stimuli (experiences). Moreover, competing gist

representations often co-exist in the “head” of the same individual, though multiple gist representations are seldom held simultaneously in working memory during higher-order cognitive processes such as judgment, decision-making, reasoning, or problem-solving. Metacognitive monitoring may help reduce discrepancies among competing gist representations, though there may be individual differences in the extent to which this occurs. It is important to note that we can express gist representations as simple clauses in natural language (i.e., English); however, when we talk about gist, we are really talking about mental representations, imprecise memory traces that are not inherently of a verbal nature.

Gist Representations of Vaccination and COVID-19

Reyna et al. (2021) provide a number of insights into vaccine hesitancy and the cognitive factors that lead some to take COVID-19 less seriously than is warranted by scientific evidence. The status quo bias is certainly one factor. Reasoning with the gist “take medicine when sick” may lead some to decide that if they are well they do not need to be vaccinated. With respect to COVID-19, many people have the gist “COVID is a deadly pandemic,” and this representation may lead people to decide in favor of a number of protective actions. However, others may have the gist representation “COVID was exaggerated to steal the election” or “COVID is exaggerated to increase government control.” Competing ideas may be mentally represented in this way and instantiated when their relevance is brought to the forefront by the context. Fuzzy Trace Theory further suggests that social values and emotions play an important role in risky decision-making. To illustrate, at different times and in different contexts, the same individuals who have the gist “I believe in science” may be furious at pharmaceutical companies such as Purdue Pharma for conspiring to addict people to oxycodone (they pled guilty in court; United States Department of Justice, 2020) while, at other times, dismissing other people for believing in crazy conspiracy theories about pharmaceutical companies, scientists, and vaccines. Others who are angry at infringements on freedom and individual liberties when a restaurant posts a sign requiring customers to wear a mask may not evoke the same gist representation when reading the sign next to it that says “No Shirt, No Shoes, No Service.”

Fuzzy-Trace Theory has shed light on some well-known framing effects, and health issues in the contemporary culture context are framed by at least three overarching and overlapping health frames. “Health and Medicine” is one frame that highlights the role of scientific data and expertise. There are two additional overarching frames that I will call “Health and Fitness” and “Health and Beauty.” Health and Fitness is usually evoked with respect to diet and exercise. These approaches frame what constitutes reasonable support for assertions and different core gist representations. For example, many people purchase organic raspberries for a variety of reasons. Many of those people have the gist “natural is good, chemicals are bad.” The Health and Beauty frame leads some people to avoid certain brands of makeup because they hold the gist that those brands “have toxins.” Importantly, people

expect different kinds of evidence for similar claims that are differently framed. Few insist on randomized clinical trials to prove that organic berries are healthier or that people with advanced degrees are the most legitimate critics of beauty products. Questions about whether vaccines are safe evoke the Health and Medicine frame for many, and gist about the value of science. Yet, it appears that some who are hesitant about vaccines are evoking the Health and Fitness or Health and Beauty frames and making decisions on the gist that “chemicals are bad” and not natural. Conversely, when people hold the gist that vaccines are “safe and effective,” it typically means they are safe and effective *as medicine*. Temporary side effects such as pain, swelling, redness, chills, and fatigue are deemed mild in the Health and Medicine frame—but few, if anyone would call them mild as the consequences of using rouge or eating raspberries. Of course, it is possible for people to sort through these distinctions through metacognitive monitoring, but at the expense of significant cognitive effort.

Contested Gist

The idea the same individual can form different gist representations of the same experience depending on the context, framing, and emotion has received solid empirical support by research stemming from Fuzzy-Trace Theory (Reyna et al., 2021). However, situations, where the bottom-line meaning of events is understood to be actively contested, have received less research attention. The way people make sense of multiple kinds of information from different sources they perceive as competing and contradictory to arrive at gist representations is in need of further investigation. Here the psychological literature on argumentation may provide some insights. For example, Wolfe, Gao, Wu, & Albrecht, 2018 found that people were more likely to agree with neutral claims after they read arguments with supporting reasons than claims alone—even arguments with implausible or ridiculous reasons such as “Dawn should make her bed because good looking rooms attract wish-granting genies.” Similarly, undergraduate American history and environmental science majors agreed more with implausible arguments than claims alone in those domains (Wolfe, Gao, Wu, & Albrecht, 2018). It appears that most any reason is better than none. Wolfe, Britt, & Butler, 2009 found that in evaluating brief written arguments, agreement with the argument was primarily weighted towards claims, whereas evaluations of the strength or quality of arguments were primarily weighted towards supporting reasons. However, Weil & Wolfe (2021) found that politically conservative participants weighted claims about vaccination more heavily in rating both agreement and argument strength or quality. Thus, it did not matter whether the claim “Companies should not require the COVID19 vaccine for their employees” was supported by the reason “because this would be a violation of personal freedom” or “because companies cannot be trusted with a responsibility that should be given to the government”—even though pilot testing indicated that the first reason was perceived as conservative and the second reason liberal. Further research is needed into arguments about vaccination and COVID-19, but it appears that people will be influenced by even ridiculous

reasons supporting an existing belief, but also that in a polarized environment, people exhibit a strong “myside bias” (Wolfe, 2012; Wolfe, Britt, & Butler, 2009) with other side arguments apparently having little effect on gist representations.

Unfortunately, the internet abounds with misinformation about vaccines and COVID-19. At least until recently, misinformation about vaccination was easily found on YouTube (Tang et al., 2021), and most YouTube vaccination videos were negative (Donzelli et al., 2018). In our own research about the web-based information and misinformation about vaccination, we found that web pages found in searches revealing concerns about vaccination were more likely to contain misinformation, an overarching gist, and narratives than other vaccination web pages (Wolfe, Eylem, Dandignac, Nabor, et al., 2021) and that pages presenting medical misinformation about vaccination were significantly more likely than other web pages about vaccination to have links to them from other pages (Wolfe, Eylem, Dandignac, Lowe, et al., 2021). Moreover, research suggests that people are quite poor at remembering the sources of information (Britt & Aglinskias, 2002; Rouet et al., 2020). Thus, it appears that when faced with multiple and competing sources of information people are likely to accept even poor support consistent with pre-existing beliefs, under-weight other-side arguments, and forget the sources of good and bogus information. I suspect that when reading false claims such as “Bill Gates invented COVID-19 so that he could put microchips in people,” in conjunction with other anti-vaccination information, some people may develop the gist “there are many reasons not to be vaccinated,” without having to believe all of them. Unfortunately, rational arguments against particular outrageous claims about vaccination would appear to have little effect on the way people represent the bottom-line meaning.

Shortcomings of and Limitations of Fuzzy-Trace Theory

Fuzzy-Trace Theory has evolved and expanded in response to new data. It is interesting to chart the progress of the theory from Reyna & Brainerd (1995) important interim synthesis to the Reyna et al. (2021) recent paper. However, every theory has shortcomings and limitations, and Fuzzy-Trace Theory is no exception. One potential issue concerns social affiliation and gist representation. We have seen that information about vaccines may, depending on the context, evoke different social values, be they “the public good” or “individual liberty,” which in turn may shape gist representations of events such as vaccination mandates. However, one wonders if there are also social affiliations that influence thinking. The notion that “we think like this” may play a larger role in evoking relevant gist representations above and beyond the values of autonomous individuals. After all, specific gist representations do not “just happen” to be found disproportionately in the minds of many white, middle-class, middle-aged, rural American men. The desire to see, talk about, and think about the world in much the same way as other people in one’s church, neighborhood, vocation, social media group, and so on, may be an under-appreciated determinant of the way gist representations are formed.

More broadly, Fuzzy-Trace Theory is not immune from the limits of all disciplinary theories in psychology. At a micro level, important work has aided understanding of some of the neurological underpinnings of gist and verbatim processing (e.g., Romer et al., 2017). However, at a macro level, the way processes of gist formation and decision making “play out” in very different cultures may fruitfully be addressed through interdisciplinary collaboration. Integrating cognitive and cultural levels of analysis through interdisciplinary collaborations among psychologists applying Fuzzy-Trace theory and cultural anthropologists are likely to be fruitful, as would interdisciplinary collaborations with researchers in other disciplines, including political science. Farther afield, interdisciplinary collaboration with scholars in the humanities might shed light on how authors of fiction parsimoniously convey gist in literature. Of course, readers of *Journal of Applied Research in Memory and Cognition* are likely to be more interested in applied interdisciplinary integration with fields such as computer science, medicine, and public health. The inherent limits of psychology may be overcome through interdisciplinary integration of Fuzzy-Trace Theory with insights from other disciplines.

Conclusions

Fuzzy-Trace Theory is a practical theory yielding novel, falsifiable hypotheses and guidance for medical decision-making tools and health interventions (Blalock & Reyna, 2016; Wolfe et al., 2015, 2016). Vaccine hesitancy and the anti-vaccination movement appear to be growing, threatening the pace and extent of recovery from the COVID-19 pandemic, and backsliding in combatting other viruses (Hussain, Ali, Ahmed, & Hussain, 2019). A key to reducing vaccine hesitancy and counteracting digital disinformation is to help people form useful and accurate gist representations of complex concepts. Interventions are most likely to improve risky decision-making when they cue core values and adaptive emotions in context in order to help people understand the bottom-line meaning of concepts related to viruses, vaccines, and COVID-19. Possible directions for future work include understanding how social affiliation affects the way gist representations are formed and interdisciplinary integration with insights from other disciplines at different levels of analysis. Overcoming vaccine hesitancy and unhealthy behaviors will require a number of tools stemming from applied research on memory and cognition, with many of the most promising tools arising from Fuzzy-Trace Theory in the battle for the gist in the public mind.

Conflict of Interest

The author declares that there is no conflict of interest.

References

- Blalock, S. J., & Reyna, V. F. (2016). Using Fuzzy-Trace Theory to understand and improve health judgments, decisions, and behaviors: A literature review. *Health Psychology, 35*(8), 781–792.
- Bransford, J. D., & Franks, J. J. (1971). The abstraction of linguistic ideas. *Cognitive Psychology, 2*, 331–350.
- Bransford, J. D., & Johnson, M. K. (1972). Contextual prerequisites for understanding: Some investigations of comprehension and recall. *Journal of Verbal Learning and Verbal Behavior, 11*(6), 717–726.
- Britt, M. A., & Aglinskias, C. (2002). Improving students’ ability to identify and use source information. *Cognition & Instruction, 20*(4), 485–522. https://doi.org/10.1207/S1532690XCI2004_2.
- Broniatowski, D. A., Jamison, A. M., Johnson, N. F., Velasquez, N., Leahy, R., Restrepo, N. J., Dredze, M., & Quinn, S. C. (2020). Facebook pages, the “Disneyland” measles outbreak, and promotion of vaccine refusal as a civil right, 2009–2019. *American Journal of Public Health, 110*(S3), S312–S318. <https://doi.org/10.2105/AJPH.2020.305869>.
- Bransford, J. D. & Franks, J. J. (1971). The abstraction of linguistic ideas. *Cognitive Psychology, 2*, 331–350.
- Cowan, N. (2000). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences, 24*(1), 87–185.
- Donzelli, G., Palomba, G., Federigi, I., Aquino, F., Cioni, L., Verani, M., Carducci, A., & Lopalco, P. (2018). Misinformation on vaccination: A quantitative analysis of YouTube videos. *Human Vaccines & Immunotherapeutics, 14*(7), 1654–1659. <https://doi.org/10.1080/21645515.2018.1454572>.
- Graesser, A., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review, 101*(3), 371–395.
- Gamliel, E., & Kreiner, H. (2020). Applying Fuzzy-Trace Theory to attribute-framing bias: Gist and verbatim representations of quantitative information. *Journal of Experimental Psychology – Learning, Memory, and Cognition, 46*(3), 497–506.
- Graesser, A. C., McNamara, D. S., & Kulikowich, J. M. (2011). Coh-Metrix: Providing multilevel analysis of text characteristics. *Educational Researcher, 40*(5), 223–234.
- Fetters, A. & De Vynck, G. (2021, September 12). *How wellness influencers are fueling the anti-vaccine movement*. The Washington Post. <https://www.washingtonpost.com/technology/2021/09/12/wellness-influencers-vaccine-misinformation/>.
- Kahneman, D. (2003). Perspective on judgment and choice: Mapping bounded rationality. *American Psychologist, 58*(9), 697–720.
- Landauer, T. K., Foltz, P. W., & Laham, D. (1998). An introduction to latent semantic analysis. *Discourse Processes, 25*(2–3), 259–264.
- Hussain, A., Ali, S., Ahmed, M., & Hussain, S. (2019). The anti-vaccination movement: A regression in modern medicine. *Cureus, 10*(7), e2919. <https://doi.org/10.7759/cureus.2919>.
- Mayo Clinic (2021). U.S. COVID-19 vaccine tracker: See your state’s progress. Retrieved September 18, 2021 from <https://www.mayoclinic.org/coronavirus-covid-19/vaccine-tracker>.
- Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*(2), 81–96.
- Reyna, V. F. (2008). A theory of medical decision making and health: Fuzzy Trace Theory. *Medical Decision Making, 28*(6), 850–865.
- Reyna, V. F. (2012). A new intuitionism: Meaning, memory, and development in Fuzzy-Trace Theory. *Judgment and Decision Making, 7*(3), 332–359.
- Reyna, V. F. (2021). A scientific theory of gist communication and misinformation resistance, with implications for health, education, and policy. *Proceedings of the National Academy of Sciences of the United States of America, 118*(15) e1912441117. <https://doi.org/10.1073/pnas.1912441117>.

- Reyna, V. F., & Brainerd, C. J. (1995). Fuzzy-trace theory: An interim synthesis. *Learning and Individual Differences*, 7(1), 1–75.
- Reyna, V. F., Broniatowski, D. A., & Edelson, S. (2021). Viruses, vaccines, and COVID-19: Explaining and improving risky decision making. *Journal of Applied Research in Memory and Cognition*, 10(4), 491–509.
- Reyna, V. F., Corbin, J. C., Weldon, R. B., & Brainerd, C. J. (2016). How Fuzzy-Trace Theory predicts true and false memories for words, sentences, and narratives. *Journal of Applied Research in Memory and Cognition*, 5(1), 1–9.
- Romer, D., Reyna, V. F., & Satterthwaite, T. D. (2017). Beyond stereotypes of adolescent risk taking: Placing the adolescent brain in developmental context. *Developmental Cognitive Neuroscience*, 27, 19–34.
- Rouet, J.-F., Saux, G., Ros, C., Stadler, M., Vibert, N., & Britt, M. A. (2020). Inside document models: Role of source attributes in readers' integration of multiple text contents. *Discourse Processes*, 58(1), 60–79. <https://doi-org.proxy.lib.miamioh.edu/10.1080/0163853X.2020.1750246>.
- Setton, R., Wilhelms, E., Weldon, B., Chick, C., & Reyna, V. (2014). An overview of judgment and decision making research through the lens of Fuzzy Trace Theory. *Advances in Psychological Science*, 22(12), 1837–1854.
- Tang, L., Fujimoto, K., Amith, M., Cunningham, R., Costantini, R. A., York, F., Xiong, G., Boom, J. A., & Tao, C. (2021). “Down the rabbit hole” of vaccine misinformation on YouTube: Network exposure study. *Journal of Medical Internet Research*, 23(1). <https://doi.org/10.2196/23262> e23262.
- Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, 185(4157), 1124–1131.
- United States Department of Justice, (2020, November 24). *Opioid Manufacturer Purdue Pharma Pleads Guilty to Fraud and Kickback Conspiracies*. Retrieved October 2, 2021 from <https://www.justice.gov/opa/pr/opioid-manufacturer-purdue-pharma-pleads-guilty-fraud-and-kickback-conspiracies>.
- Wolfe, C. R. (2012). Individual differences in the “MySide bias” in reasoning and written argumentation. *Written Communication*, 29(4), 474–498.
- Wolfe, C. R., Eylem, A. A., Dandignac, M., Nabor, D. H., Wang, C., Biragbara, D., Scudiere, L., & Reyna, V. F. (2021). Understanding the landscape of web-based information about vaccination [Manuscript in preparation].
- Weil, M. A. & Wolfe, C. R. (2021). Individual Differences in Risk Perception and Misperception of COVID-19 in the Context of Political Ideology [Manuscript in preparation].
- Wolfe, C. R., Eylem, A. A., Dandignac, M., Lowe, S. R., Weber, M. L., Scudiere, L., & Reyna, V. F. (2021). Understanding the landscape of web-based medical misinformation about vaccination [Manuscript in preparation].
- Wolfe, C. R., Britt, M. A., & Butler, J. A. (2009). Argumentation schema and the myside bias in written argumentation. *Written Communication*, 26(2), 183–209.
- Wolfe, C. R., Gao, H., Wu, M., & Albrecht, M. (2018). Most any reason is better than none: Consequences of plausible and implausible reasons and warrants in brief written arguments. *Written Communication*, 35(3), 255–285.
- Wolfe, C. R., Reyna, V. F., Widmer, C. L., Cedillos-Whynott, E. M., Brust-Renck, P. G., Weil, A. M., & Hu, X. (2016). Understanding genetic breast cancer risk: Processing loci of the BRCA Gist intelligent tutoring system. *Learning & Individual Differences*, 49, 178–189. <https://doi.org/10.1016/j.lindif.2016.06.009>.
- Wolfe, C. R., Reyna, V. F., & Brainerd, C. J. (2005). Fuzzy-trace theory: Implications for transfer in teaching and learning. In *Transfer of learning from a modern multidisciplinary perspective* (ed. J. P. Mestre). Information Age Press, Greenwich, CT, pp. 53–88.
- Wolfe, C. R., Reyna, V. F., Widmer, C. L., Cedillos, E. M., Fisher, C. R., Brust-Renck, P. G., & Weil, A. M. (2015). Efficacy of a web-based Intelligent tutoring system for communicating genetic risk of breast cancer: A Fuzzy-Trace Theory approach. *Medical Decision Making*, 35(1), 46–59, 0272989X14535983.

Received October 5, 2021
Accepted October 13, 2021