 doi:10.20944/preprints202101.0263.v1

Review

Critical Thinking: A Model of Intelligence for Solving Real-world Problems

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Abstract: Most traditional theories of intelligence have little to do with the question of whether people with high intelligence can successfully address real world problems. A high IQ is correlated with many important outcomes (e.g., academic prominence, reduced crime), but it does not protect against cognitive biases, partisan thinking, reactance, confirmation bias, and even falling for discredited beliefs such as alchemy, cold fusion, and astrology. There are several newer theories that directly address the question about solving real-world problems. Prominent among them is Sternberg's adaptive intelligence with "adaptation to the environment" as the central premise, a construct that does not exist on standardized IQ tests (e.g., Sternberg, 2019). Similarly, Stanovich and West (2014) argue that standardized tests of intelligence are not measures of rational thought—the sort of skill/ability that would be needed to address complex real-world problems. Halpern and Butler (2020) advocate for critical thinking as a better model of intelligence for addressing real-world problems than those that are based on psychometric properties of general intelligence. Yes, intelligence (i.e., critical thinking) can be enhanced and used for solving a real-world problem like Covid-19, which we use as an example of contemporary problems that need a new approach. Critical thinking may be an antidote for the chaos of the modern world.

Keywords: critical thinking; intelligence; real-world problems

1. Introduction

The editors of this special issue asked authors to respond to a deceptively simple statement, "**How Intelligence Can Be a Solution to Consequential World Problems.**" This statement holds many complexities, including how intelligence is defined and which theories are designed to address real-world problems.

2. The Problem with Using Standardized IQ Measures for Real-world Problems

For the most part, we identify high intelligence as having a high score on a standardized test of intelligence. Like any test score, IQ can only reflect what is on the given test. Most contemporary standardized measures of intelligence include vocabulary, working memory, spatial skills, analogies, processing speed, and puzzle-like elements (e.g., Wechsler Adult Intelligence Scale Fourth Edition; see Drozdik et al., 2012). Measures of IQ correlate with many important outcomes including academic performance (Kretzschmar et al., 2016), job-related skills (Hunter & Schmidt, 1996), reduced likelihood of criminal behavior (Burhan et al., 2014), and for those with exceptionally high IQs, obtaining a doctorate and publishing scholarly articles (McCabe et al., 2020). But the fact that many variables correlate with scores on tests of general intelligence does *not* mean that intelligence caused the outcomes. For example, additional years of

schooling could be the cause of increases in IQ and unidentified variables could be causing both (e.g., affluent neighborhoods, private school educations, healthy diets).

The problem is that having a high IQ does not protect against falling for cognitive fallacies (e.g., blind spot bias, reactance, anecdotal reasoning), relying on biased and blatantly one-sided information sources, failing to consider information that does not conform to one's preferred view of reality (confirmation bias), resisting pressure to think and act in a certain way, among others. This point was clearly articulated by Lilienfeld and colleagues (2020), who described the sometimes strange beliefs of Nobel Prize winners, people who were recognized for the highest work in the world in their discipline, including economics, medicine, and chemistry.

In a classic and extensive study of the IQs of preeminent scientists, Roe (1953) estimated the IQ of the most eminent scientists, both in the past and those living at that time. Her list included luminaries in mathematics, astronomy and physics. She estimated the IQs of some of the most famous scientists, including Darwin, Copernicus, Kepler, Newton, LaPlace and others. These estimates ranged from a low of 160 to a high of 190. Although these data are more than 60 years old, her conclusion that world-class scientists have exceptional IQs is shared in contemporary sources. Rothenberg and Wyshak (2004) confirm that most people believe that Nobel Prize Winners are geniuses. Lilienfeld and colleagues (2020) found that some of the people with the highest awards for work in their field nonetheless believe in alchemy (changing metal to gold), phrenology (determining personality by studying bumps on the head), cold fusion, astrology, facilitated communication (for people with autism), and many more discredited beliefs. Many of the weird ideas held by these brilliant scientists include important real-world problems such as climate change. For example, Muller, who shared the 1993 Noble Prize in chemistry, called the idea that humans are causing climate change—an idea supported by 97% of climate scientists and 200 scientific organizations (NASA, 2020) —pathetic.

3. Which Theories of Intelligence are Relevant to the Question?

Most of the traditional theories of intelligence have little to do with the question of whether people with high intelligence can successfully address real world problems. Biological theories focus on brain structures and neural processes (of course, intelligence must have an underlying biological substrate, but that does not address the problem). Cognitive process theories emphasize, for example, reaction-time measures, working memory, and inspection time. Psychometric theories posit the importance of a general factor, or "g," which also says nothing about the relationship to real-world questions. Grossman, et al., (2013) cite many studies in which IQ scores have not predicted well-being, including life satisfaction and longevity. But there are several newer theories that directly address the question about solving real-world problems. Prominent among them is Sternberg's adaptive intelligence with "adaptation to the environment" as the central premise, a construct that does not exist on standardized IQ tests (e.g., Sternberg, 2019). Similarly, Stanovich and West (2014) argue that standardized tests of intelligence are not measures of rational thought—the sort of skill/ability that would be needed to address complex real-world problems. Halpern and Butler (2020) advocate for critical thinking

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(CT) as a better model of intelligence for addressing real-world problems than those that are based on psychometric properties of general intelligence. Although there is much overlap among these more recent theories, we use Halpern and Butler's conceptualization to make our point: Yes, intelligence (i.e., CT) can be enhanced and used for solving a real-world problem like Covid-19.

4. Critical Thinking as an Applied Model for Intelligence

One of our favorite definitions of intelligence comes from Nickerson (2020, p 205): "**the ability to learn, to reason well, to solve novel problems, and to deal effectively with novel problems—often unpredictable—that confront one in daily life.**" Using this definition, the question of whether intelligent thinking can solve a world problem like the coronavirus is a resounding "yes" because solutions to real-world novel problems are part of his definition.

Two components of critical thinking are (1) understanding information at a deep, meaningful level and (2) appropriate use of CT skills. The underlying idea is that critical thinking skills can be identified, taught, and learned, and when they are recognized and applied in novel settings, the individual is demonstrating intelligent thought. Critical thinking skills include judging the credibility of an information source, making cost-benefit calculations, recognizing regression to the mean, understanding the limits of extrapolation, muting reactance responses, rating the strength of reasons that support and fail to support a conclusion, and recognizing hindsight bias or confirmation bias, among others. Critical thinkers use these skills appropriately, without prompting, and usually with conscious intent in a variety of settings. There is a longer list of critical thinking skills in Halpern and Dunn (in press). All of these skills can be taught, learned, and applied to novel problems.

There is a large and growing empirical literature to support this assertion. See for example, Holmes et al. (2015), who wrote in the prestigious *Proceedings of the National Academy of Sciences,* that there was "significant and sustained improvement in students' critical thinking behavior" (p. 11199) for students who received critical thinking instruction. Abrami et al., (2015, para 1) concluded from a meta-analysis that "there are effective strategies for teaching CT skills, both generic and content specific, and CT dispositions, at all educational levels and across all disciplinary areas." Abrami et al., (2008, para 1), wrote: "findings make it clear that improvement in students' CT skills and dispositions cannot be a matter of implicit expectation." The strongest test of whether critical thinking skills can be used for real-word problems comes from research by Butler et al. (2017). Community adults and college students (N = 244) completed several scales including an assessment of critical thinking, an intelligence test, and an inventory of real-life events. Both critical thinking scores and intelligence scores predicted individual outcomes on the inventory of real-life events, but critical thinking was a stringer predictor than intelligence scores, and it significantly added to the explained variance. For other references that support the conclusion that critical thinking is a useful model of intelligence, see for example, Heijltjes et al., (2015), Heijltjes et al., (2014), Halpern et al., (2012)—and many others that can be found in Halpern and Dunn (in press).

5. Pandemics: COVID-19 as a Consequential Real-World Problem

A pandemic occurs when a disease runs rampant over an entire country or even the world. Pandemics have occurred throughout history: At the time of writing this article, COVID19 is a world-wide pandemic whose actual death rate is unknown but estimated with projections of several million over the course of 2021 and beyond (Mega, 2020). Although vaccines are available, it will take some time to inoculate most or much of the world's population. Since March 2020, national and international health agencies have created a list of actions that can slow and hopefully stop the spread of COVID (e.g., wearing face masks, practicing social distancing, avoiding group gatherings), yet many people in the United States and other countries have resisted their advice. The questions then become whom to trust when evaluating information about the efficacy of masks and what are the costs and benefits of wearing and not wearing a mask.

Could instruction in critical thinking encourage more people to accept and comply with simple life-saving measures? There are many possible reasons to believe that by increasing citizens' critical thinking abilities, this problematic trend can be reversed for, at least, some unknown percentage of the population. Critical thinking can be an antidote for the chaos of the modern world with armies of bots creating content on social media, political and other forces deliberately attempting to confuse issues, and almost all media labeled "fake news" by social influencers (i.e., people with followers that sometimes run to millions on various social media).

Credibility of the Source of Information

Early communications about the ability of masks to prevent the spread of COVID from national health agencies were not consistent. In many regions of the world, the benefits of wearing masks incited prolonged and acrimonious debates (Tang, 2020). However, after the initial confusion, virtually all of the global and national health organizations (e.g., WHO, National Health Service in the U. K., U. S. Centers for Disease Control and Prevention) endorse masks as a way to slow the spread of COVID (Cheng et al., 2020; Chu et al., 2020). But as we know, some people do not trust governmental agencies and often cite the conflicting information that was originally given as a reason for not wearing a mask. There are varied reasons for refusing to wear a mask, but the one most often cited is that it is against civil liberties (Smith, 2020). Reasoning by analogy is an appropriate CT skill for evaluating this belief. It might be useful to cite some of the many laws that already regulate our behavior such as, requiring health inspections for restaurants, setting speed limits, mandating seat belts when riding in a car, and establishing the age at which someone can consume alcohol.

Could training in critical thinking change the beliefs and actions of even a small percentage of those opposed to wearing masks? Such training would include considering the following questions with practice across a wide domain of knowledge: a) Does the source have sufficient expertise? b) Is the expertise recent and relevant? c) Is there a potential for gain by the information source such as getting more money? d) What would be the ideal information source and how close is the current source to the ideal? e) Does the information source offer evidence that what they are recommending is likely to be

correct?, f) Have you traced URLs to determine if the information in front of you really came from the alleged source? and so on. Of course, not everyone will respond in the same way to each question, so there is little likelihood that we would all think alike, but these questions provide a framework for evaluating credibility. Imagine the effect of rigorous large-scale education in critical thinking from elementary through secondary schools, as well as at the university-level. As stated above, empirical evidence has shown that people can become better thinkers with appropriate instruction in critical thinking. With training, could we encourage some portion of the population to become more astute at judging the credibility of a source of information? It is an experiment worth trying.

6. Making Cost -Benefit Assessments for Actions that Would Slow the Spread of COVID-19

Citizens are asked to wash their hands, wear face masks, and avoid crowds which are often perceived as limitations on personal freedoms, triggering psychological reactance. For many people the government should have as little interference in their lives as possible. Historical records show that refusal to wear a mask during a pandemic is not a new reaction. The epidemic of 1918 also included mandates to wear a mask, which drew public backlash. Then, as now, many people refused, even when they were told that it was a symbol of "wartime patriotism" because the 1918 pandemic occurred during World War I (Lovelace, 2020). There are multiple ways to address this problem: Critical thinking instruction would include instruction in why and how to compute cost-benefit analyses. Estimates of "lives saved" by wearing a mask can be made meaningful with graphical displays that allow more people to understand large numbers. Gigerenzer (2020) found that people can understand risk ratios in medicine when the numbers are presented as frequencies instead of probabilities. If this information were used when presenting the likelihood of illness and death from COVID-19, could we increase the numbers of people who understand the severity of this disease? Small scale studies by Gigerenzer have shown that it is possible.

Analyzing Arguments to Determine Degree of Support for a Conclusion

The process of analyzing arguments requires that individuals rate the strength of support for and against a conclusion. By engaging in this practice, they must consider evidence and reasoning that may run counter to a preferred outcome. Kozyreva et al. (2020) call this deliberate ignorance—avoiding or failing to consider information that could be useful in decision-making because it may collide with an existing belief. When applied to COVID-19, people would have to decide if the evidence for and against wearing a face mask is a reasonable way to stop the spread of this disease, and if they conclude that it is not, what are the costs and benefits of not wearing masks at a time when governmental health organizations are making them mandatory in public spaces? Again, we wonder if rigorous and systematic instruction in argument analysis would result in more positive attitudes and behaviors that relate to wearing a mask or other real-world problems. We believe that it is an experiment worth doing.

7. Conclusion

We believe that teaching critical thinking is a worthwhile approach for educating the general public in order to improve reasoning and motivate actions to address, avert, or ameliorate real-world problems like the COVID-19 pandemic. Evidence suggests that critical thinking can guide intelligent responses to societal and global problems. We are NOT claiming that critical thinking skills will be a panacea for the many real-world problems that we confront in contemporary society, or that everyone will substitute critical thinking for other decision-making practices, but we do believe that systematic education in critical thinking can help many people become better thinkers, and we believe that this is an important step toward creating a society that values and practices critical thinking. The challenges are great, but the tools to tackle them are available if we are willing to use them.

References

Abrami, P. C., Bernard, R.M., & Borokhovski, Waddington. D. I., Wade, A.C. , (2015). Strategies for teaching students to think critically: A meta-analysis. *Review of Educational Research,* https://doi.org/10.3102/0034654314551063

Abrami, P. C., Bernard, R. M., Borokhovski, E., Wade, A., Surkes, M. A., Tamim, R., & Zhang, D. (2008). Instructional interventions affecting critical thinking skills and dispositions: A Stage 1 meta-analysis. *Review of Educational Research, 78,* 1102-1134.

Burhan , K. A. , Kurniawan , Y. , Sidek , A. H. , & Mohamad , M. R. (2014). Crimes and the Bell curve: Th e role of people with high, average, and low intelligence . *Intelligence* , 47 , 12 – 22 . doi:http:// dx.doi.org/ 10.1016/ j.intell.2014.08.005

Butler, H. A., Pentoney, C., & Bong, M. P. (2017). Predicting real-world outcomes: Critical thinking ability is a better predictor of life decisions than intelligence. *Thinking Skills and Creativity, 25,* 38-46. https://doi.org/10.1016/j.tsc.2017.06.005

Cheng, V. C-C, Wong, S-K, Chuang, V. W-M., So, S. Y-C., Chen, J. H-K., Sridhar, S., To, K. K-W., Chan, J. F-W., Hung, I F-N., Ho, P-K., & Yuen, K-Y. (2020, April, 23). The role of community-wide wearing of face mask for control of coronavirus disease 2019 (COVID-19) epidemic due to SARS-CoV-2. *Journal of Infectious Disease,* U. S. National Library of Medicine National Institutes of Health. doi: 10.1016/j.jinf.2020.04.024

Chu, D.K., Aki, E. A., Duda, S., Solo, K.,Yaacoub, S., & Schunemann, H. J. (2020, June 27). Physical distancing, face masks, and eye protection to prevent person-to-person transmission of SARS-CoV-2 and COVID-19: A system atic review and meta-analysis. *Lancet* (London, England). doi: 10.1016/S0140-6736(20)31142-9

Drozdick, L. W., Wahlstrom, D., Zhu, J., & Weiss, L. G. (2012). *The Wechsler Adult Intelligence Scale—Fourth Edition and the Wechsler Memory Scale—Fourth Edition.* In D. P. Flanagan & P. L. Harrison (Eds.), *Contemporary intellectual assessment: Theories, tests, and issues* (p. 197–223). The Guilford Press.

Gigerenzer, G. (2020). When all is just a click away: Is critical thinking obsolete in the digital age? In R. J. Sternberg & D. F Halpern (Eds) (pp. 197-223). *Critical thinking in psychology* 2nd ed. (pp197-223). Cambridge University Press.

Grossman, I., Varnum, M. E. W., Na, J., Kitayama, S., & Nisbett, R. E. (2013). A route to well-being: Intelligence versus wise reasoning. *Journal of Experimental Psychology: General, 142*, 944-953.

Halpern, D. F., & Butler, H. A. (2020). Is critical thinking a better model of intelligence? In Sternberg, R. J. (Ed.). *The nature of intelligence (2nd ed.)* pp. 183-196. Cambridge University Press.

Halpern, D. F. & Dunn, D. S. (in press). *Thought and knowledge: An introduction to critical thinking,* 6th Ed. Taylor & Francis.

Halpern, D. F., Millis, K., Graesser. A., Butler, H., Forsyth, C. & Cai, Z. (2012). Operation ARA: A computerized learn ing game that teaches critical thinking and scientific reasoning. *Thinking Skills and Creativity, 7,* 93-100.

Heijltjes, A., van Gog, T., Lippink, J., & Paas, F. (2015). Unraveling the effects of critical thinking instructions, practice, and self-explanation on students' reasoning performance. *Instructional Science,* 43,487-506. DOI 10.1007/s11251-015-9347-8

Heijltjes, A., van Gog, T., & Paas, F. (2014). Improving students' critical thinking: Empirical support for explicit in structions combined with practice. *Applied Cognitive Psychology, 28,* DOI: 10.1002/acp.3025

Holmes, N. G., Wieman, C. E., & Bonn, D. A. (2015). Teaching critical thinking. *Proceedings of the National Academy of Sciences, 112, 11199-11204.* doi: 10.1073/pnas.1505329112

Hunter , J. E. & Schmidt , F. L. (1996). Intelligence and job performance: Economic and social implications . *Psychol ogy, Public Policy, and Law* , 2 , 447 – 472

Kozyreva, A., Lewandowsky, S., & Hertwig, R. (2020, December 14). Citizens versus the internet: Confronting digital challenges with cognitive tools. *Psychological Science in the Public Interest, 21, https://www.psychologi calscience.org/publications/confronting-digital-challenges-with-cognitive-tools.html*

Kretzschmar , A. , Neubert , J. C. , Wusternberg , S. , & Greiff , S. (2016). Construct validity of complex problem- solv ing: A comprehensive view on different facts of intelligence and school grades *Intelligence, 54* , 55 – 69 . http:// dx.doi.org/ 10.1016/ j.inell.2015.11,004 .

Lilienfeld, S. O., Basterfield, C., Bowes, S.M., & Costello, T. H. (2020). Nobelists gone wild: Case studies in the domain specificity of critical thinking. In R. J. Sternberg, & D. F. Halpern *Critical thinking in psychology* 2nd ed.(pp 10-18). Cambridge University Press.

Lovelace, B., Jr. (2020, September 28). Medical historians compare the coronavirus to the 1918 flu pandemic: Both were highly political. *CNBC.* https://www.cnbc.com/2020/09/28/comparing-1918-flu-vs-corona virus.html?fbclid=IwAR1RAVRUOIdN9qqvNnMPimf5Q4XfV-pn_qdC3DwcfnPu9kavwumDI2zq9Xs

McCabe, K. O., Lubinski, D., & Benbow, C. P. (2020). Who shines most among the brightest?: A 25-year longitudinal study of elite STEM graduate students. *Journal of Personality and Social Psychology, 119(2),* 390–416. https://doi-org.ccl.idm.oclc.org/10.1037/pspp0000239.supp (Supplemental)

Mega, E. R. (2020, September 30). COVID has killed more than one million people. How many more will die? *Nature,* https://www.nature.com/articles/d41586-020-02762-y NASA (2020). Scientific consensus: Earth's climate is warming. https://climate.nasa.gov/scientific-consensus/

Nickerson, R. S (2020). Developing intelligence through instruction. In R. J. Sternberg. (Ed.) *The Cambridge Handbook of Intelligence 2nd ed.* (pp 205-237). Cambridge University Press.

Roe, A. (1953). *The making of a scientist.* Dodd, Mead.

Rothenberg, A. & Wyshak, G. (2004). Family background and genius II: Nobel laureates in science. *Canadian Journal of Psychiatry.* 85-91.

Smith, M. (2020, July 15). Why won't Britons wear face masks? *YouGov,* https://yougov.co.uk/topics/health/articles-reports/2020/07/15/why-wont-britons-wear-face-masks

Stanovich, K. E., & West, R. F. (2014). What intelligence tests miss. *The Psychologist, 27,80-83.*

Sternberg, R. J. (2019). A theory of adaptive intelligence and its relation to general intelligence. *Journal of Intelligence, 7,* 1-17, doi: 10.3390/jintelligence7040023.

Tang, J. W. (2020). COVID-19: Interpreting scientific evidence—uncertainty, confusion, and delays. *BMC Infectious dis eases, U. S. National Library of Medicine National Institutes of Health*. doi: 10.1186/s12879-020-05387-8