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How Intelligence Can Be a Solution to Consequential World Problems

Edited by
Robert J. Sternberg, Andrew R. A. Conway and Diane F. Halpern

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Preface to "How Intelligence Can Be a Solution to Consequential World Problems"

The late James Flynn of the University of Otago in New Zealand, to whom this book is dedicated, observed what has become one of the most significant findings in the psychology of intelligence—that during the 20th century, IQs rose, all over the world, on average, roughly 30 points. This finding was so significant to the field of intelligence, and to the field of abilities, more generally, because intelligence, at least as measured by conventional intelligence tests, had been thought to be relatively stable, both over secular time and over the life of a person. Yet, here was what seemed to be an incredible gain—two standard deviations—during the course of just a century. How was that possible? No one knew when Flynn made the discovery and, to this day, no one knows for sure.

Flynn believed that the increase was due to the increased complexity and challenges the world presented to people, and his explanation makes sense. However, at the same time this explanation potentially answers one question, it also raises another, perhaps deeper question. If IQs rose such that the average IQ now is what once would have been called a "gifted IQ," how is it that people are doing such a wholly inadequate job of coping with the world's problems. Indeed, people are largely creating those problems: senseless wars to feed the egos of war-makers, global climate change, extreme income disparities, pollution, a repeatedly faltering response to a global pandemic, terrorism, crime, and the flourishing of autocracies and outright dictatorships. It would appear that higher IQs are largely powerless to solve these problems, and, in part, may even have contributed to them by enabling people to deploy their mental abilities in ways that are harmful rather than helpful to the world.

This book addresses the problem of why world problems seem, as we go to press, to be increasing rather than decreasing, why IQ has been largely powerless to solve them, and what kinds of intellectual and other resources might be deployed to address these pressing problems. Make no mistake, these are serious problems resulting in millions of deaths on a continuing basis. We owe it to our children and their children to try to solve these problems. In this book, we try at least to set down paths that might help us reach viable solutions.

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Perspective

Intelligence Can Be Used to Make a More Equitable Society but Only When Properly Defined and Applied

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Abstract: In the US, undeniable evidence shows that socioeconomic inequities explain a high proportion of individual differences in school achievement. Although not all countries show this same effect due to socioeconomic status, it is consistently found that social inequities lead to achievement gaps. These achievement gaps then manifest into trajectories that set some individuals on a path of lower incomes, poorer health and higher mortality, lower wellbeing, and other poor adult outcomes. Like James Flynn so handily reminded the scientific literature that achievement gaps are explainable by environmental factors, the inequities we see around the world are based on environments some children are exposed to. In his work, Flynn stated his belief that the suppression of scientific work on intelligence would continue to lead to social inequities. We wish to take this idea and move it forward. We believe that the scientific construct of intelligence plays a key role in helping create a more equitable society through science. We also believe that the poor perception of intelligence, rooted in historical realities, means that it will continue to be misunderstood, feared, and misused, limiting how effective it could be in helping to close gaps in achievement and in creating a more equitable society.

Keywords: intelligence; inequity; social issues

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1. Introduction

In the US, undeniable evidence shows that social inequities explain a high proportion of individual differences in school achievement. We define social inequities as group differences in access to resources based on race/ethnicity and skin color due to social and structural discrimination. The differences in access to resources contribute to disparities felt by these groups, including achievement gaps. Achievement gaps are when marginalized individuals tend to perform lower on standardized school achievement tests than White individuals (e.g., Jeynes 2015; Norman et al. 2001; Taylor 2006). These achievement gaps then manifest into trajectories that set some individuals on a path of lower incomes, poorer health and higher mortality, lower wellbeing, and other poor adult outcomes (Beck and Muschkin 2012; Caro 2009; Taylor 2006). Here we address the real-world problem of achievement gaps—unexplainable other than by social inequities—and layout our opinion that the scientific construct of intelligence must be considered in helping reduce these achievement gaps, and therefore plays a key role in helping create a more equitable society.

A conventional definition of intelligence is that it represents a person's ability to adapt to new and changing environments, and by extension, people are thought to vary in this ability. If we replaced "intelligence" with a new term, most people would read the previous sentence and think that term sounds like a useful scientific construct. We understand that for many, the claim that including intelligence in work examining the achievement gap is controversial. The fact is that intelligence is a controversial construct and is often not included in scientific projects, including those on the achievement gap. We believe that this is due to the poor perception of intelligence—rooted in historical realities—which has

led to it being misunderstood, feared, and misused, also limiting how effective it could be to work towards a more equitable society. Intelligence as a construct has been left behind by much of scientific research and replaced with more socially favorable constructs that remove historical baggage but do not have the same depth of prediction (e.g., executive function, self-regulation, see Daucourt et al. 2018). With our paper, we wish to propose that the concept of intelligence is too important to lose in our science, but we must first properly define intelligence, recognize the history of its previous application, and consider the appropriate application of intelligence in modern society.

2. Defining Our Modern Notion of Intelligence

In Spearman's (1904) pioneering work using factor analysis, he claimed that it was possible to not only assess cognitive ability, but that one could do so objectively through a latent factor of ability, which he coined *g*, or the general factor of intelligence. Spearman observed what is now called the positive manifold—the finding that performance on one cognitive ability task is highly positively correlated with performance on other tasks. This remains one of the most highly replicated findings in psychology and psychometric literature (Spearman 1904; Conway and Kovacs 2015). Although Spearman defined intelligence in terms of a single psychometric factor *g*, modern work defines intelligence as the emergent interaction of a variety of domain specific and domain general cognitive processes (see Alfano et al. 2016; Van der Maas et al. 2006; Thomson 1916), deemed Process Overlap Theory (Kovacs and Conway 2016). Here, we focus on this modern definition of intelligence with the formative *g* approach supplied by Process Overlap Theory.

Conway and Kovacs (2015) outline the reflective and formative models of *g*. The idea behind the reflective model is that if someone is higher on *g*, they will have a higher IQ score compared to someone lower on g, and the variance in latent *g* determines the variance in the measure. The reflective model assumes a fixed perspective of ability in that *g* is thought to be responsible for one's performance as well as the variance we see in other measures. On the other hand, the formative model of *g* implies that *g* emerges from the positive manifold we observe between many measures of cognitive ability. In the formative model, *g* does not cause performance but rather performance on diverse cognitive measures causes *g* to emerge (Conway and Kovacs 2015). Whereas reflective models of intelligence suggest that there are limitations in terms of how much improvement is possible for test performance—based on forms of intervention—the formative model of *g* allows us to refocus the conversation. Instead of viewing *g* as the innate and fixed cause of all intelligent and adaptive behavior, we can refocus on how formative models allow for a better understanding of how to better tailor forms of intervention. We believe that by improving tailoring forms of intervention we can better address modern issues surrounding social inequities and their impact on a variety of future life outcomes.

Kovacs and Conway (2019) argue that because *g* is emergent, intelligence or IQ is not "real" and should not be viewed as general cognitive ability. Instead, *g* is an index that emerges from several real abilities on a variety of diverse subtests. In line with this, Gottfredson (1997) states that intelligence goes beyond just test scores or test performance, but instead reflects aspects such as "figuring out what to do". Others argue that intelligence test scores are essentially a representation of what the assessment measures (Farmer et al. 2020; Van der Maas et al. 2014). Thus, we should think more deeply about how the scores on intelligence tests are obtained and what different submeasures of IQ mean, especially for solving real world problems. Based on Kovacs and Conway, there are three levels of evaluation that future research might focus on for intervention purposes: the subtests, the specific factors, and the global scores or the general factor of intelligence. In the formative approach—moving beyond simply exploring the higher order concept of global IQ—investigating specific abilities allows for a more informed understanding of intelligence and where there might be room for intervention. We will unpack this more, but first, we want to briefly consider what the literature finds on the question of whether or not intelligence is improvable.

'Intelligence as improvable' is contrary to early definitions and some modern views consider it innate and relatively unchangeable (Jensen 1969, 1998). In terms of ways to improve intelligence, there is evidence showing that performance on some intelligence tests is at least in part malleable and trainable (Binet 1909/1973; Cury et al. 2008; Gould 1981; Flynn 1984; Jaeggi et al. 2008; also see Jaeggi et al. 2011; 2013; Redick et al. 2013; also see Nisbett et al. 2012). For example, some show that fluid intelligence might be improvable via working memory (see Baddeley and Hitch 1974) training (Au et al. 2015; Jaeggi et al. 2008, although this is not without controversy, e.g., Redick et al. 2013; Shipstead et al. 2012). Some early forms of intervention (Protzko et al. 2013) and education can improve intelligence scores (Ritchie and Tucker-Drob 2018), and individual differences factors underlying intelligence scores change across the lifespan due to contextual factors (Haworth et al. 2010; Tucker-Drob and Bates 2016). Moreover, it has been argued by some that scores on intelligence tests are biased and influenced by cultural differences (Cattell 1949; Williams 1972), which are subject to situational and environmental influences making intelligence "socially situated" (Rogoff and Lave 1984; Walton 2013). These findings bring up important points about the role of context, the person, and the tool, in impacting differences in performance on intelligence measures. Collectively, however, these findings show that performance on tests of intelligence is improvable, a fact that we argue can be useful.

With a more targeted focus on where there might be room for improvement, Kovacs and Conway (2019) imply that subtests and specific factors that compose a global index of intelligence would prove more useful than focusing on a global index or the general factor of intelligence alone. This is worth considering as an avenue for future research to further examine the efficacy and utility of intelligence to better support marginalized students. Considering the underlying specific abilities that make up global IQ, the specific abilities level is optimal because as Kovacs and Conway state: "it is specific enough to allow for a meaningful reflective interpretation but global enough to not be entirely task specific". Formative models of *g* provide the benefit of focusing more on lower order specific abilities (i.e., fluid, spatial, and verbal specific abilities) because they are real, and beyond being statistically emergent (like global IQ or *g*), they have predictive validity. This allows us to find ways to improve performance and achievement with intervention, targeting lower-order submeasures of *g*. Based on this, we argue that the formative approach of *g* supplied by Process Overlap Theory has the power to uncover new forms of more tailored intervention and can also help to minimize forms of adverse impact but only when intelligence scores are correctly interpreted and applied as Kovacs and Conway advise. To get to this next step and implement the approach outlined above, we feel that it is important to further examine how the historical realities of intelligence have obstructed its use and application for a more equitable society.

3. Issues with Intelligence, and Why They Get in the Way of Equity Goals

The study and use of intelligence have been marred by its original roots in eugenics (see Harden 2021). Beyond eugenics, throughout the century and a half since intelligence was first conceptualized and measured, it has been used to support the marginalization of racial minorities and impoverished communities (see Beeghley and Butler 1974) and forced the sterilization of individuals with developmental disabilities (Buck v Bell, see Russell 2009). It has been widely misused to support nationalistic and white supremacist agendas by taking the individual differences score measured by an intelligence test and applying it to group differences, such as the so-called "national IQ" (Lynn 2010; also see Wicherts et al. 2010). The consistent finding of moderate heritability on intelligence has been twisted to inaccurately imply biological determinism and immutability of intelligence (see van Dijk et al. 2021, for what heritability means; see also Turkheimer et al. 2003 for a different approach to thinking about heritability). The conceptualization of intelligence was originally rooted in a Western Upper-class European culture, and that does not universally apply to all cultures around the world (e.g., Sternberg et al. 2001). Furthermore, our

understanding of intelligence is almost entirely limited to samples that lack racial and ethnic diversity, as well as being "WEIRD," or White, Educated, Industrialized, Rich, and Democratic (Henrich et al. 2010). We take the stand here acknowledging that diversity and inclusion related concerns as it pertains to research are important. We argue that white nationalistic agendas have contributed to a lack of appropriate representation and ethical participation of marginalized groups in the science of intelligence. This, in turn, has undoubtedly contributed to the construct of intelligence being underappreciated in groups who have traditionally been stigmatized or disenfranchised by definitions and applications of intelligence in the real world. However, by avoiding the construct of intelligence, we have ignored what the construct has to offer in terms of helping to solve a real-world problem related to social inequities: achievement gaps.

4. How Can the Modern Notion of Intelligence Address Real World Inequity Problems?

When our modern notion of intelligence, as defined above, is used empirically, it is shown to predict many real-world outcomes—such as everything from better academic performance in school to getting divorced, to the number of offspring, and even the risk of early death (see Ritchie 2015). Certainly, it could be argued that very few constructs predict more useful outcomes than intelligence, and here we argue that modern notions of intelligence including a formative approach with submeasures of *g* allowing users to solve problems related to social inequities existing in achievement gaps. Next, we discuss two specific real-world problems related to intelligence and achievement: the effects of stereotype threat and learning disabilities.

4.1. Stereotype Threat

In terms of social inequity and the impact on performance, for some, the stigma associated with belonging to certain group identities could influence additional variation and induce a form of measurement bias when being assessed on tests of achievement (see Wicherts et al. 2005). This may come from worries of being stereotyped based on aspects attributed to certain social or group identities (Steele and Aronson 1995). For example, Steele and Aronson demonstrate the power that a particular social situation can have on cognitive performance. By inducing threat—making some negative aspect of group membership salient—those under threat suffered significantly decreased task performance relative to control groups. Threat has been shown to interfere with attentional control on the anti-saccade task (Jamieson and Harkins 2007), increase anxiety and lower standardized test performance (Steele and Aronson 1995), and deplete cognitive resources in the short and long term (Inzlicht and Schmeichel 2012; Schmader and Johns 2003; also see Schmader et al. 2008). Threat has also been shown to interfere with initial learning and impact later memory for studied information (Taylor and Walton 2011). There is also evidence that threat effects interact with trait measures of working memory for women and minorities (Holden et al. 2020; Regner et al. 2010).

With the domain general processes of working memory (as a submeasure of intelligence) being shown as a protective factor for cognitive control and performance, it becomes important to examine ways to enhance working memory. As discussed above, it is unclear whether working memory training improves intelligence; however, there is more evidence that working memory itself is improvable through working memory training (Jaeggi et al. 2008; Redick et al. 2013) and mindfulness practices (Mrazek et al. 2013). Forms of mindfulness practices not only provide psychological and physical health benefits (Grossman et al. 2004; Prazak et al. 2012) but have also been shown to combat negative thought processes like task unrelated thoughts and mind wandering while promoting forms of goal maintenance and attentional control processes (Morrison and Jha 2015) which are also important general processes involved in working memory and intelligence (Conway et al. 2003; also see Kane and Engle 2003). Based on Process Overlap Theory (see Kovacs and Conway 2019), further investigating the interaction of a variety of domain general and domain specific processes of intelligence and ways to support or boost performance on

submeasures of intelligence like working memory capacity should be beneficial to students who contend with psychologically threatening situations. Taking this one step further, these forms of intervention may help some of our most marginalized students enhance their test performance. In fact, motivated by inconsistencies in the effectiveness of interventions for stereotype threat, recent meta-analytic work by Liu et al. (2021) found that both person and situation centric approaches helped to counter stereotype threat. They show that belief and identity-based interventions helped most, followed by resilience-based ones. Belief-based interventions focus on changing negative beliefs, emphasizing the promotion of positive beliefs and belonging; whereas, identity-based interventions involve activation of positive aspects of one's identity in order to help counter stereotype threat and its effects. Resilience based interventions (such as those we argue for here) involve activating self-regulatory processes that aid in helping individuals to cope with stereotype threat and its effects in a more adaptive way. Furthermore, future work should further investigate the efficacy of a combination of these intervention approaches. Theoretically, additional forms of support that help marginalized students combat stereotype threat, contributes to better performance trajectories (Cohen et al. 2017; Yeager and Walton 2011), helping to potentially close gaps in achievement and support a variety of improved-life outcomes whether psychologically, physically, and/or economically (see DeWalt et al. 2004).

Some might believe that the approach we are arguing for is deficit based. To those who think that way, let us clearly and emphatically state: that is simply not true. Those who are marginalized in science and society are not to blame for issues of systemic inequities and societal bias. Those who are the most marginalized in society contend with forms of inequity, including prejudice, stereotyping, and discrimination. Instead of viewing this as a deficit of those who are the targets of these issues, we argue that our approach is all about empowering the targets while they navigate systems that are unfair, biased, and oppressive. We believe that forms of changing unfair systems and structures are also important, and we feel that this should happen *in tandem with* empowering those who face many obstacles every day within slow-changing and unfair systems. We acknowledge that forms of social psychological intervention (e.g., Growth Mindset, Social Belonging, and Self Affirmation, see Yeager and Walton 2011) have been aimed at marginalized students and we believe that in addition to that work, more can be done in the area of intelligence to find forms of cognitive support for students as well. Through the approaches we argue for here, we are centering the experiences of the marginalized and working to include them in our science on intelligence in ways that are both empowering and strengths focused. We wish to acknowledge the truth about what marginalized individuals are often forced to contend with while also finding ways to leverage individual strengths to better tailor forms of intervention to support diverse needs. We are arguing that intelligence research can be applied in this way but only if researchers are willing to acknowledge that differences in experiences also means being understanding of and amenable to differences in needs. Moreover, with the participation of the marginalized and most vulnerable being misused for unethical scientific purposes and excluded or underrepresented in the basic science for so long, there should be a sense of urgency for inclusion, justice, and the instantiation of reparative science that allows for greater beneficence for these groups. Next, we turn to the topic of learning disabilities to further consider how intelligence research can be beneficial.

4.2. Learning Disabilities

In the US, Black, Hispanic, Asian, Native American, and language-minority children are overrepresented in special education services (see Morgan et al. 2016, 2018 as to whether this represents a discriminatory overrepresentation or an underrepresentation; see also Woods et al. 2021). There is a history of using a reflective notion of intelligence to understand and define learning disabilities. For example, the IQ-achievement discrepancy definition of dyslexia states that dyslexia can only occur when reading performance is below what would be expected from ability, measured as IQ. The idea is that a child with low intelligence would be expected to also struggle to read, and therefore would not

have dyslexia, a domain specific disorder, but instead have global struggles. However, the evidence does not support the idea that individuals who only struggle with reading are different than individuals who have lower intelligence and also struggle to read, casting much doubt on the IQ-achievement discrepancy definition (e.g., Toth and Siegel 2020). Rather than using a reflective notion of intelligence, by using a formative model of intelligence, intelligence tests, which are highly reliable measures, can be used to determine a pattern of strengths and weaknesses for each child in special education. This leads to an individual-differences perspective to our identification of learning disabilities and how we instruct children.

There is good reason to believe that fully understanding individual differences in student performance, including the role of intelligence and its mechanisms, will help us better identify students who will struggle and differentiate our instruction to meet the needs of every student (Connor et al. 2009; Cronbach and Snow 1977; Fuchs and Fuchs 2018). For example, executive function is a good indicator of reading difficulties (Daucourt et al. 2018), suggesting that mechanisms of intelligence might be good indicators of hybrid models of learning disabilities (e.g., Fletcher et al. 2013; Wagner 2008). Phonological awareness, rapid naming speed, alphabetic-principle knowledge, reading skill, and memory capacity have all also been shown to be important individual differences predictors of which children will respond to educational interventions for at risk or struggling readers (Al Otaiba and Fuchs 2002; Coyne et al. 2018; Hart et al. 2016). Considering this, we argue that precision education is an intervention approach (Hart 2016) motivated by the idea that different students have different needs and that we should be aiming to uncover how to better tailor forms of intervention.

5. A Thorny Problem and Conclusions

We admit that we were high-level in our discussion of how intelligence can be applied to help close achievement gaps, specifically considering the effects of stereotype threat and the identification and treatment of learning disabilities. We conclude here by discussing standardized testing, which is a thorny real-world problem where thinking about formative intelligence can be useful in some ways of better understanding achievement gaps, but not all.

Recently, there has been an uptick in conversation about the utility of standardized testing and whether they contribute to bias in the academic admissions process (see Michel et al. 2019). There are layers to this conversation that must be distinguished for the sake of clarity. First, some believe that standardized tests like the SAT and GRE (often viewed as synonymous with intelligence) are inherently biased such that they favor White and Asian test-takers and higher SES persons over minority students and lower SES persons. In turn, some argue that standardized tests and particularly the GRE should be optional or potentially abandoned. We will tackle the issue of test bias with two main points. First, the topic of bias in standardized testing has been addressed by the College Board and the Educational Testing Service (ETS) which works to create and administer the SAT and GRE. ETS ensures that their tests are corrected for potential bias from the item level through the entire assessment considering the diversity and multicultural nature of their client-base (Educational Testing Service 2018, Fairness Guidelines), so these tests are unbiased, statistically speaking. Second, where standardized tests are concerned, the biggest problem with inequality stems from access to preparation materials and differences in socioeconomic status that influence access and preparation. As such, these kinds of barriers can mean that these tests are rooted in the inequality that is inherent in society. From the formative perspective, submeasures and subtests are not able to remove or account for forms of social bias inherent in society that might "unlevel the playing field" and impact achievement. As of yet, intelligence tests, like many tests, do not statistically control for these types of differences (we refer the reader to Hartocollis 2019 on the College Board's proposed privilege and adversity index and its subsequent retraction). This means intelligence is not, nor should it be, thought of as the "end all, be all". As such, we must keep intelligence

scores, like other test scores, in context and be thoughtful about what these scores tell us and consider the limitations of what they cannot tell us[1].

When thinking more critically about leveling the playing field, we believe that standardized tests, an exemplar of intelligence tests, *can* offer a way to consistently evaluate what we believe to be statistically unbiased measures of cognitive abilities but only to the extent that intelligence is properly understood, defined, and applied. On the contrary to arguments about bias in standardized tests and intelligence measures, we argue that testing such as this *can* give students from disadvantaged backgrounds the chance to stand out and overcome disadvantages[2]. For example, we believe that through a formative *g* approach with Process Overlap Theory, we can generate and test new and meaningful hypotheses about how to combat issues of inequities in education and achievement. Through science, we can then develop more tailored forms of intervention to meet a diversity of needs. In the end, our society is ever-evolving. It seems obvious that a measure of adaptability to a changing environment should be important to our science and our society. As intelligence researchers, we must identify and reconcile the ghastly history surrounding intelligence, we must relegate the nefarious actors who wish to twist intelligence into a discriminatory tool to the corner, and we must thoughtfully research how intelligence can help us towards an equitable society. Like Flynn (1999) so handedly reminded the scientific literature that achievement gaps are explainable by environmental factors, the inequities we see around the world are based on environments some children are exposed to. In the same work, Flynn stated his belief that the suppression of scientific work on intelligence would continue to lead to social inequities. By simply ignoring intelligence or replacing it with a less precise but more fashionable construct, we are ignoring a key tool in cultivating a more equitable society.

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Notes

1 There have been recent debates on the related topic of going 'test optional'. We argue that making standardized tests optional, or even abandoning them, is not necessarily better for reducing bias and inequality in the admissions process overall. With going 'test optional', the question becomes: how do administrators compare students who are similar in grades and experience when one has a standardized test score and one does not? Further, if the students both have stellar letters of recommendation, should the standardized test score for one student be ignored? What forms of bias would this process introduce that have not been previously considered? Moreover, under circumstances of completely abandoning test scores, administrators must rely even more heavily on letters of reference in addition to grades, and we know that forms of bias and inequality are baked into those as well (Miller et al. 2021; Morgan et al. 2013; also see Kumar and Hamer 2013). For example, teachers and administrators are themselves biased (Haughbrook 2020; also see Riddle and Sinclair 2019).

2 As an example, we note the finding that minority and lower SES students are less likely to be identified and recommended for gifted programs (Research News @Vanderbilt 2016). It has been estimated that over 3.6 million students in the US should be labeled as gifted who are not, and this is thought to be the case because minority and lower SES students are largely ignored and not encouraged by their instructors (Hechinger Report 2019; Grissom and Redding 2016). Some have found that underperformance of minority students is driven by greater levels of implicit bias in teachers, and this effect has been explained by greater levels of anxiety and lower levels of lesson quality (Jacoby-Senghor et al. 2016). On the other hand, implementation of universal screening programs (which involve the administration of cognitive aptitude tests), apart from parent and teacher referrals, alone found substantial increases in those identified for giftedness from disadvantaged backgrounds, minority students, and traditionally underrepresented students (Card and Giuliano 2016).

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Commentary

It Requires More Than Intelligence to Solve Consequential World Problems

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Abstract: What are consequential world problems? As "grand societal challenges", one might define them as problems that affect a large number of people, perhaps even the entire planet, including problems such as climate change, distributive justice, world peace, world nutrition, clean air and clean water, access to education, and many more. The "Sustainable Development Goals", compiled by the United Nations, represent a collection of such global problems. From my point of view, these problems can be seen as complex. Such complex problems are characterized by the complexity, connectivity, dynamics, intransparency, and polytely of their underlying systems. These attributes require special competencies for dealing with the uncertainties of the given domains, e.g., critical thinking. My position is that it is not IQ, but complex problem-solving competencies for dealing with complex and dynamic situations, that is important for handling consequential global problems. These problems require system competencies, i.e., competencies that go beyond analytical intelligence, and comprise systems understanding as well as systems control. Complex problem solving is more than analytic intelligence.

Keywords: grand societal challenges; Sustainable Development Goals; complex problems; consequential world problems

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1. Introduction

The editors of this Special Issue have asked me to respond to the statement: "How intelligence can be a solution to consequential world problems". What exactly are consequential world problems? Why should intelligence (intelligent behavior) be relevant to their solutions? What other skills would help in solving global problems? The answer I give here to these questions is based on my personal opinion, rather than on an evidence-based review of the literature.

Who defines "consequential world problems"? It is not easy to scale and prioritize the challenges to mankind, because there are many different perspectives. Lomborg (2007) tried to define "the world's biggest problems" in terms of costs and benefits. However, for me (as a German, remembering that the Nazis used the term "life unworthy of life" [in German: "lebensunwertes Leben"] to evaluate different qualities of life), this approach suffers from the issue of giving a monetary value to human life. I cannot follow the idea that you can compensate a human life for money, in line with the belief that "all lives are equal".

How, then, to define global problems? As "grand societal challenges", one might define them as problems that affect a large number of people, perhaps even the entire planet, including problems such as climate change, distributive justice, world peace, world nutrition, clean air and clean water, access to education, and many more.

2. The Challenges

The world around us presents many challenges to mankind—not only human-driven climate change but also the demand for food and water for a global population that may

soon reach 8 billion people. Clean air and clean water are not widely available in large parts of the world, driving migration from failed states to more promising ones.

The United Nations have compiled 17 "Sustainable Development Goals" that represent a collection of such global problems. These goals are concerned with the survival of planet Earth and its inhabitants. They are the blueprint to achieve a better and more sustainable future for all. They address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace, and justice.

What is psychology's answer to these grand societal challenges? The research on problem solving is my preferred perspective on these challenges. Problem solving is a processual view on intelligence (see, e.g., Sternberg 1982). This research arena has produced various different approaches for dealing with nonroutine situations.

3. Proposed Solution: The "General Problem Solver"

The "General Problem Solver" (Newell et al. 1959) was, at its time (in the 1950s and 1960s), a promise to solve all problems with an algorithm. However, that promise did not hold—as it turned out, it was more a kind of "special" problem solver that could deal with well-defined problems but not with ill-defined ones. Real-world (ill-defined, "wicked") problems normally show a series of attributes that simple (well-defined) problems lack:

- There is no clearly defined goal;
- There is more than just one ("the one and only") solution;
- Information needed for the solution has to be actively searched for;
- There are dynamics in the problem situation (one cannot wait forever for a solution).

Today's version of this is called "artificial intelligence". This again promises to solve problems of many different types, but again, there is some disillusion concerning AI's abilities when considering "adversarial perturbations" (e.g., Metzen et al. 2017) and missing explanations from deep-learning "black-box" algorithms (e.g., Rudin 2019).

4. Dealing with Uncertainty: Solving Complex Problems

As a consequence of the limitations of problem-solving research focused on puzzles, towers, and other "toy problems", the use of computer-simulated microworlds was proposed (e.g., Brehmer and Dörner 1993). The use of microworlds within a controlled laboratory environment allowed the introduction of attributes that characterize uncertain situations and complex problems (see Dörner and Funke 2017; Funke 2019). According to Funke (2019, p. 167), a complex problem shows the following features: (1) *complexity*, in the sense that many variables are involved; (2) *connectivity*, reflecting the fact that relationships exist between variables; (3) *intransparency*, referring to missing or inaccessible information important for the problem-solving process; (4) *dynamics*, in the sense of the possibility of changes of a given situation over time; and (5) *polytely* (from the Greek word 'polytelos', meaning many goals), referring to there being many goals and objectives that are possible and could be pursued.

How are complex problems different to complicated problems? For complicated problems, solutions exist, and experts are needed (and found); for complex problems, there are no experts available, because these problems are novel and have no known solution (see Kurtz and Snowden 2003).

Contrary to expectations, the successful handling of complex problems does not correlate with intelligence (as measured by classical tests of intelligence), according to early studies (for a review, see Kluwe et al. 1991; Wenke et al. 2005). However, Wittmann and Süß (1999) pointed out that these negative results might be due to a Brunswikian asymmetric relationship between the dependent variables (single-act criteria on the side of complex problems and multiple-act criteria on the side of intelligence).

Research with "minimally complex problems" (as they were developed within PISA 2012; see Csapó and Funke 2017; Funke and Greiff 2017) showed that scores from these tasks explained about 10% of the variance in grade point average beyond test intelligence (Wüstenberg et al. 2012). However, concerning the validity of the "minimally complex

systems", questions and doubts remain (see, e.g., Funke 2014; Funke et al. 2017). To explore and control minimally complex problems, strategies such as VOTAT ("vary one thing at a time") may be helpful (Schoppek and Fischer 2017), but in real life, they cannot be recommended as a useful strategy. For example, you normally cannot vary the mood of your boss (or other potentially influential variables) to test the possible hypothesis that, while in a sad mood, she/he might give you more difficult tasks than when in a happy mood. In complex situations, simple variations of single factors are neither possible (because there are too many variables) nor conclusive (you cannot control the influence of other explanatory causes).

Systems competencies seem to be more important than intelligence (Funke et al. 2018). In the 21st century, skills such "critical thinking" (e.g., finding and evaluating relevant information; Halpern and Dunn 2021), understanding the complexities and dynamics of large systems, and dealing with uncertainty better represent the requirements of life than finding the correct answer to a number-series task (as tends to be requested in conventional tests of intelligence).

What are the cognitive proficiencies of systems thinking? Systems thinking involves a collection of cognitive and noncognitive features. It is a holistic approach, switching between a bird's eye view and a detailed view, remaining calm and persistent in the pursuit of goals, and showing empathy for the acting persons, instead of focusing on simple cause–effect chains, with a preference for systemic thinking about loops with positive or negative feedbacks.

Based on the proposed model, I illustrate more in detail how system competencies could be applied in practice. For this purpose, I considered an important contemporary real-world problem, namely climate change. Analytical intelligence (based on rational choice assumptions) might argue that, with respect to the anticipated rising sea level and myself living far above sea level, there is no threat to me as a person. However, with empathy (as part of a broader understanding of intelligence), one could imagine the threat to people living on an island in the Pacific Ocean exposed to a rising sea level.

5. Ethical Values, Character Formation, and Wisdom

Our current concept of intelligence is missing an ethical dimension. During the education process of individuals, we do not solely teach facts and knowledge; we also teach values. The education process, in general, is a process of character formation. One of the long-term results of character formation can be seen in the development of wisdom. Tuchman (1984, p. 21) defined wisdom as: "the exercise of judgment acting on experience, common sense and available information." Is wisdom the result of successful character formation?

In her recent review, Glück (2019, Table 16.1, p. 310) presented twelve definitions of wisdom. Only one of them mentions "values" explicitly, namely the "balance theory of wisdom" from Sternberg (1998). According to that theory, wise people know that different people can have different values. This idea of "value relativism" in wise people is also one of the five criteria for wisdom within the Berlin wisdom paradigm (see, e.g., Baltes and Staudinger 2000). However, to know that there are different perspectives on dilemmata does not imply that one has clear moral values—it is a kind of metaknowledge, free of any special content. Values allow for "sinn" (German, "meaning") in life.

Similarly, Fischer (2015) argued for a context-free view of wisdom and saw it as "independent of one's values and context." On the other hand, Fischer collected 12 propositions that were commonly known to wise men from four different cultures (Socrates, Jesus, Confucius, and Buddha). These four wise individuals show parallels concerning certain wise content (e.g., Proposition 10: "Good people (and children) make good company"). Once again, there is no comment about the acquisition of these pieces of wisdom. Reading such "wise" propositions does not make us a wise person instantaneously. To become a wise person is a process that normally demands time and life experience. Wisdom should be one of the competencies of good leaders.

The University of Cambridge Institute for Sustainability Leadership (CISL), as reported by Visser et al. (2016), examined leadership theories and leadership development framed within the United Nations Sustainable Development Goals (SDGs), which were launched in September 2016. The CISL summarized the elements of a 'good' global leader into a model based on earlier research by Visser and Courtice (2011). This approach argued that a leader operating with a global perspective, and in a complex context, should have seven characteristics: capacity to be a systems thinker, proficiency in navigating complexity, open-minded, long-term thinker, interdisciplinary, inclusive, and globally conscious.

6. Conclusions

Complexity continues to increase, and creative solutions to complex problems are urgently needed (e.g., Mainzer 2009; Puccio 2017). To address societal needs, intelligence must be enriched by an ethical dimension. Sternberg (2019, 2021a) uses the term "adaptive" as a qualification for a new perspective of intelligent behavior. From my point of view, intelligence in all its forms is adaptive. The new perspective is on society and on the survival of mankind and therefore takes value into account. Here, "menschenbild" (our view on man) matters; the metaphors of man have shifted from "homo oeconomicus" (skeptically: Sen 1977) over "homo ignorans" (Hertwig and Engel 2016) to "homo curans" (man that cares; see, e.g., Tronto 2017). The deployment of "transformational intelligence" (Sternberg 2021b) also comes into play. To quote Fyodor Dostoyevsky (1821–1881): "It takes something more than intelligence to act intelligently" (from his book *Crime and Punishment*). This "something more" could be values and wisdom. "Values" adds to the noncognitive variables and "wisdom" to the cognitive variables. This could make an important difference.

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Review

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

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Abstract: Most theories of intelligence do not directly address the question of whether people with high intelligence can successfully solve 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, or confirmation bias, among others. 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. Similarly, some scholars 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. Other investigators advocate for critical thinking as a model of intelligence specifically designed for addressing real-world problems. Yes, intelligence (i.e., critical thinking) can be enhanced and used for solving a real-world problem such as COVID-19, which we use as an example of contemporary problems that need a new approach.

Keywords: critical thinking; intelligence; real-world problems

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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 (Drozdick et al. 2012)). Measures of IQ correlate with many important outcomes, including academic performance (Kretzschmar et al. 2016), job-related skills (Hunter and 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). Gottfredson (1997, p. 81) summarized these effects when she said the "predictive validity of g is ubiquitous." More recent research using longitudinal data, found that general mental abilities and specific abilities are good predictors of several work variables including job prestige, and income (Lang and Kell 2020). Although assessments of IQ are useful in many contexts, having a high IQ does not protect against falling for common 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 Stanovich (2009, p. 3) when he stated that," IQ tests measure only a small set of the thinking abilities that people need."

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

Most theories of intelligence do not directly address the question of whether people with high intelligence can successfully solve real world problems. For example, Grossmann et al. (2013) cite many studies in which IQ scores have not predicted well-being, including life satisfaction and longevity. Using a stratified random sample of Americans, these investigators found that wise reasoning is associated with life satisfaction, and that "there was no association between intelligence and well-being" (p. 944). (critical thinking [CT] is often referred to as "wise reasoning" or "rational thinking,"). Similar results were reported by Wirthwein and Rost (2011) who compared life satisfaction in several domains for gifted adults and adults of average intelligence. There were no differences in any of the measures of subjective well-being, except for leisure, which was significantly lower for the gifted adults. Additional research in a series of experiments by Stanovich and West (2008) found that participants with high cognitive ability were as likely as others to endorse positions that are consistent with their biases, and they were equally likely to prefer one-sided arguments over those that provided a balanced argument. 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 CT as a useful model of intelligence for addressing real-world problems because it was designed for this purpose. Although there is much overlap among these more recent theories, often using different terms for similar concepts, 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 definition of intelligence that directly addresses the question about intelligence and real-world problem solving 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 novel coronavirus is a resounding "yes" because solutions to real-world novel problems are part of his definition. This is a popular idea in the general public. For example, over 1000 business managers and hiring executives said that they want employees who can think critically based on the belief that CT skills will help them solve work-related problems (Hart Research Associates 2018).

We define CT as the use of those cognitive skills or strategies that increase the probability of a desirable outcome. It is used to describe thinking that is purposeful, reasoned, and goal directed–the kind of thinking involved in solving problems, formulating inferences, calculating likelihoods, and making decisions, when the thinker is using skills that are thoughtful and effective for the particular context and type of thinking task. International surveys conducted by the OECD (2019, p. 16) established "key information-processing competencies" that are "highly transferable, in that they are relevant to many social contexts and work situations; and 'learnable' and therefore subject to the influence of policy." One of these skills is problem solving, which is one subset of CT skills.

The CT model of intelligence is comprised of two components: (1) understanding information at a deep, meaningful level and (2) appropriate use of CT skills. The underlying idea is that CT skills can be identified, taught, and learned, and when they are recognized and applied in novel settings, the individual is demonstrating intelligent thought. CT 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, using analogical reasoning, 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.

One of the key concepts in this model is that CT skills transfer in appropriate situations. Thus, assessments using situational judgments are needed to assess whether particular skills have transferred to a novel situation where it is appropriate. In an assessment created by the first author (Halpern 2018), short paragraphs provide information about 20 different everyday scenarios (e.g., A speaker at the meeting of your local school board reported that when drug use rises, grades decline; so schools need to enforce a "war on drugs" to improve student grades); participants provide two response formats for every scenario: (a) constructed responses where they respond with short written responses, followed by (b) forced choice responses (e.g., multiple choice, rating or ranking of alternatives) for the same situations.

There is a large and growing empirical literature to support the assertion that CT skills can be learned and will transfer (when taught for transfer). 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. 11,199) for students who received CT 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), included 341 effect sizes in a meta-analysis. They wrote: "findings make it clear that improvement in students' CT skills and dispositions cannot be a matter of implicit expectation." A strong test of whether CT 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 CT, an intelligence test, and an inventory of real-life events. Both CT scores and intelligence scores predicted individual outcomes on the inventory of real-life events, but CT was a stronger predictor.

Heijltjes et al. (2015, p. 487) randomly assigned participants to either a CT instruction group or one of six other control conditions. They found that "only participants assigned to CT instruction improved their reasoning skills." Similarly, when Halpern et al. (2012) used random assignment of participants to either a learning group where they were taught scientific reasoning skills using a game format or a control condition (which also used computerized learning and was similar in length), participants in the scientific skills learning group showed higher proportional learning gains than students who did not play the game. As the body of additional supportive research is too large to report here, interested readers can find additional lists of CT skills and support for the assertion that these skills can be learned and will transfer in Halpern and Dunn (Forthcoming). There is a clear need for more high-quality research on the application and transfer of CT and its relationship to IQ.

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, COVID-19 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.

Could instruction in CT encourage more people to accept and comply with simple life-saving measures? There are many possible reasons to believe that by increasing citizens' CT abilities, this problematic trend can be reversed for, at least, some unknown percentage of the population. We recognize the long history of social and cognitive research showing that changing attitudes and behaviors is difficult, and it would be unrealistic to expect that individuals with extreme beliefs supported by their social group and consistent with their political ideologies are likely to change. For example, an Iranian cleric and an orthodox rabbi both claimed (separately) that the COVID-19 vaccine can make people gay (Marr 2021). These unfounded opinions are based on deeply held prejudicial beliefs that we expect to be resistant to CT. We are targeting those individuals who beliefs are less extreme and may be based on reasonable reservations, such as concern about the hasty development of the vaccine and the lack of long-term data on its effects. There should be some unknown proportion of individuals who can change their COVID-19-related beliefs and actions with appropriate instruction in CT. CT can be a (partial) 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). Here, are some CT skills that could be helpful in getting more people to think more critically about pandemic-related issues.

Reasoning by Analogy and Judging the 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). However, 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 (and a key skill in legal thinking). 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. Individuals would be asked to consider how the mandate to wear a mask compares to these and other regulatory laws.

Another reason why some people resist the measures suggested by virtually every health agency concerns questions about whom to believe. Could training in CT 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 financial gain? (d) What would the ideal information source be 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?, etc. 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. Donovan et al. (2015) were successful using a similar approach to improve dynamic decision-making by asking participants to reflect on questions that relate to the decision. Imagine the effect of rigorous large-scale education in CT 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 CT. 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

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 masks, 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). CT 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 the deliberate failure to consider both supporting and conflicting data "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. Conclusions

We believe that teaching CT 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 CT can guide intelligent responses to societal and global problems. We are NOT claiming that CT skills will be a universal solution for the many real-world problems that we confront in contemporary society, or that everyone will substitute CT for other decision-making practices, but we do believe that systematic education in CT can help many people become better thinkers, and we believe that this is an important step toward creating a society that values and practices routine CT. The challenges are great, but the tools to tackle them are available, if we are willing to use them.

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Improving Gifted Talent Development Can Help Solve Multiple Consequential Real-World Problems

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Abstract: Fully developing the talents of all students is a fundamental goal for personal well-being and development and ultimately for global societal innovation and flourishing. However, in this paper we focus on what we believe is an often neglected and underdeveloped population, that of the gifted. We draw from the cognitive aptitude and gifted education research literatures to make the case that solutions to consequential real-world problems can be greatly enhanced by more fully developing the talents of the intellectually gifted population, which we operationalize in this paper as roughly the top 5% of cognitive talent. Should well-supported high achievers choose to solve them, these problems span health, science, economic growth, and areas unforeseen. We draw from longitudinal research on intellectually precocious students and retrospective research on leaders and innovators in society, showing that mathematical, verbal, and spatial aptitudes are linked to societal innovation. We then discuss two remaining fundamental challenges: the identification of disadvantaged and marginalized groups of students who have traditionally been neglected in selection for gifted programming suited to their current developmental needs, and the building of skills beyond academic ones, specifically in the related areas of open-minded thinking and intellectual humility.

Keywords: innovation; talent selection and development; gifted education; social returns; cognitive aptitudes and creativity

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1. Introduction and Roadmap

Solving consequential real-world problems would ultimately best be served by fully developing the multitude of talents of *all* individuals in society. Thus, we should without question help all students, through education and other means, to develop to their full potential. In this paper, we focus on what we believe to be an often neglected and underdeveloped population that very likely could contribute greatly to solving real-world problems to a much larger degree than they currently do (Benbow and Stanley 1996; Gardner 1961). This is the intellectually gifted population, which we operationalize as roughly the top 5% of achievers globally. Systemic and structural barriers reducing the likelihood that many talented but disadvantaged students from low-income and minority backgrounds can ultimately develop their talents and eventual expertise to the fullest is a crucial ongoing challenge (Peters 2021). When many children come from poverty, they will not only fail to be recognized as gifted, they might not even develop to be gifted (e.g., Hair et al. 2015). This is true for countries around the world where lack of opportunities and numerous headwinds (Stevens 2020; Wai and Worrell 2020) face talented but disadvantaged students (in particular compared to their advantaged counterparts). These inequalities in opportunities and challenges may have been even further exacerbated by the COVID-19 pandemic and related learning losses globally (e.g., Hanushek and Woessmann 2020), adding up to a cumulative disadvantage over time. Of course, whether talented students choose to

solve consequential real-world problems or do whatever else they want with their lives is entirely up to them. Our hope is that at least for some, choices to fulfill one's potential might also be consonant with an interest in contributing to the broader improvement of society, and it is in that hope that we write this article.

This special issue call for papers asked contributors to take one consequential real-world problem and discuss what we know about cognitive abilities that could help us to solve the problem. We reframe this question slightly to consider two areas of research informed by cognitive abilities that can help us solve *multiple* consequential real-world problems. First, we review the literature making the case that fully developed gifted students in fact already do very likely solve multiple consequential real-world problems but do so broadly very likely based on their personal interests, life circumstances, and educational and developmental trajectories in different areas of achievement and expertise. We further make the case that more fully developing the talents of gifted students or the top 5% of achievers will likely enhance the likelihood of solving real-world problems in the future. Another core problem is identifying and developing the talents of talented but disadvantaged students, especially underrepresented minorities, to ensure personal development and flourishing but also to broaden the talent pool to solve problems from a broader array of perspectives and personal talents. Broadly, we begin our article describing how developed cognitive aptitudes are important to solving real-world problems, introduce our theoretical and empirical perspective that frames the remainder of the article, and discuss issues in regard to the support and development of gifted students, and really all students, on multiple dimensions.

2. Talent Development and Innovation

In 1957 a group of scientists from the California Institute of Technology, after multiple discussions with industrialists and other leaders, published their forecasts for the most important problems facing humanity for the next 100 years. The authors (Brown et al. 1957, p. 152) concluded that "The problems which we face in the years ahead are indeed both numerous and grave, but, theoretically at least, it seems likely that they can be solved by the proper application of our intelligence." There are many strategies for applying cognitive aptitudes to real-world problems. In this article, we emphasize the importance of investing in all students, with a focus on strategies involving investment in gifted students, in particular those from disadvantaged backgrounds. Cole (2016, p. 23) described the "law of the 5 percent" as the idea that in nearly every field, the top 5% of that field will be responsible for the vast majority of innovation. We introduce the idea of investing in developing more students to be among what is currently the top 5 percent of achievers, then fully developing that broader group of achievers, who we argue have been, are, and will be largely responsible for innovation across multiple fields of intellectual and creative endeavor in the future.

Talented individuals innovate in a variety of ways that can benefit society, and are very likely to rise to positions of influence to be able to implement those innovations (Lubinski and Benbow 2020; Wai and Worrell 2016; Wai 2013). Innovations come from individuals throughout the cognitive aptitude range, and many high achieving students do not choose to solve consequential real-world problems. This suggests we should invest in developing the talents of all students, including gifted students, because as cognitive aptitudes rise, so does the *likelihood* of innovation.

Certainly, the idea of ensuring talent development is not new (Gardner 1961), and is truly a global consequential real-world problem. As researchers who work and live in the US, we are biased towards our local perspective, but also see how in many less developed nations the lack of talent development may even be more severe given greater structural and other barriers such as poverty and lack of opportunity. The US already has a number of programs for the purpose of talent development, both at the level of individual schools and at a national level. However, the availability of talent development programs varies widely. Many schools lack such programming, and the national programs have limited capacity and are often quite expensive. In a broad sense, talent development is the essence

of all education (e.g., . Subotnik et al. 2011). However, there remain many students with high potential who simply were not born into circumstances with sufficient opportunities, and whose talent is often overlooked and underdeveloped (Hair et al. 2015; Peters 2021).

In the US, this is at least in part because there remains very little federal support for gifted education (Benbow and Stanley 1996), or even any federal requirements to provide such services. Instead, the decision is up to states and school districts, and the availability of services varies widely across these settings. In many school districts, no formal gifted supports are available at all. Even when some supports are present, they rarely include all the students who should be eligible. Often, those left behind are talented students from low-income and historically marginalized backgrounds (Wai and Worrell 2016) and students with overlooked spatial talents (Lakin and Wai 2020; Wai and Lakin 2020). Some scholars argue that COVID-19 learning losses could add up to trillions (Azevedo et al. 2020). Other scholars argue that the long-run economic impact of this loss is the same as one-third of a year of schooling which translates to a gross domestic product (GDP) loss of 1.5% on average for the remainder of the century (Hanushek and Woessmann 2020; Schleicher 2020). In this context, it is crucial to ensure that talented but disadvantaged students do not get left behind.

To be clear, we should invest in all students throughout the full spectrum to develop and help them use that cognitive potential to the very best of their capacity. However, major societal problems are, again, more likely to be solved by those with the greatest developed talents, and when such problems are solved, everyone can benefit. Gifted education should therefore not be viewed as an individual reward to students for having high ability, but perhaps in part as a societal investment with a high likelihood of good returns. Even merely more optimal matching of high-aptitude individuals to jobs and settings that require the solution of complex problems is associated with more economic growth across countries (Strenze 2013). If we go beyond this matching process to actually fully develop the gifts of those with the highest developed potential, this might even lead to even greater gains. Of course, whether individual students choose to pursue certain life courses is ultimately up to them, whether that means taking advantage of opportunities that are available, finding a domain that suits their interests and aptitudes, or sustaining the years of motivation and hard work often required to attain expertise in a given domain.

3. Cognitive Aptitudes and Giftedness: Definitions

Though there are numerous verbal operationalizations of what being gifted means (e.g., for a review see . Subotnik et al. 2011), we focus on aspects of giftedness that are measurable through cognitive tests as one indicator of giftedness. More specifically, we focus on a version of the hierarchical model of abilities (Carroll 1993) known as the Radex model (Lubinski 2004), which includes general reasoning at the apex and the specific aptitudes of mathematical, verbal, and spatial. This well-established structure, at least in our view, should at least be considered part of a measurable and consistent definition of intellectual giftedness (Coleman and Cureton 1954; Detterman 1993; Thompson and Oehlert 2010; Kelley 1927). We also view all abilities as developed and that cognitive aptitudes are *current* developed capacities that an individual brings to learning or problem-solving environments at a given time (Lohman 2005; Snow 1996). All aptitudes or abilities are thus developed and malleable (. Subotnik et al. 2011; Uttal et al. 2013), and they are both important to learning and problem-solving environments such as schooling, but also an important *product* of schooling (Ceci 1991; Lohman 1993; Ritchie and Tucker-Drob 2018).

4. High Developed Aptitudes Can Often Lead to Greater Innovation

Even just a small number of academically gifted and talented scientists can improve our lives in the most remarkable of ways. Pinker (2018) summarized findings from science-heroes.com, which lists roughly 100 individuals with remarkable achievements who have made life-saving discoveries. Based on this data, Pinker (2018) argues that over 5.5 billion lives have been saved by a small cohort of 100 or so individual scientists. This includes

the discovery of the chlorination of water, smallpox eradication strategy, measles vaccine, penicillin, oral rehydration therapy, among numerous other examples. The scientists who developed the Pfizer/BioNTech COVID-19 vaccine, Katalin Kariko, Ugur Sahin, Albert Bourla, and Ozlem Tureci are contemporary examples (Gelles 2020).

Rindermann and Thompson (2011) illustrated that the cognitive 5% of a nation's population disproportionately influenced innovation and GDP of that nation. Longitudinal studies focused on the gifted population also illustrate that fully developed gifted students can earn doctorates, publications, patents, and even university tenure at the rate of two to eight times that of the general population (Lubinski and Benbow 2006, 2020; Park et al. 2007). Findings within the top 1% of aptitudes are replicated in both nonrandom (Lubinski and Benbow 2020) and random gifted samples (Wai 2014). There does not appear to be a threshold beyond which more aptitude no longer matters for a wide range of life outcomes both within gifted samples (Lubinski and Benbow 2020) and also across multiple population-representative samples in the US and UK (Brown et al. 2021). Even when drawing from a large sample of US leaders across a variety of domains such as business, the media, politics, law, and those with enormous wealth, when retrospectively profiling where these leaders attended higher education, roughly half attended educational institutions that largely selected for the top 1% of aptitude on standardized admissions tests (Wai 2013).

5. Improving Gifted Talent Development has the Potential to Enhance a Wide Range of Innovations and Social Returns

Innovation can be considered to be largely about creating something truly new and useful. Flexner and Dijkgraaf (2017), as well as Braben (1994, 2020), argued that a key for intellectual advancement is to encourage brilliant and unique minds to pursue whatever interests them—or even what goes against the current popular research topics—and to choose questions that do not necessarily have immediate application. Differential psychology (Revelle et al. 2011) shows us that people have varying interests (Su 2020), and this is true within the gifted population as well (e.g., Lubinski and Benbow 2006, 2020; Wai 2013), suggesting that different interests may be linked to wide ranging areas of innovation. Studies on cohorts of intellectually talented youths in the top 1%, top 0.5% and top 0.01% of aptitude show that as the average talent of the gifted cohort rises, so does the accomplishments of that group (Lubinski and Benbow 2006, 2020). Crucially, the range of innovation of these talented youths is spread across a wide array of domains, from science, technology, engineering, and mathematics (STEM) fields to the humanities, heads of business, partners in law firms, and publication of novels. Coupled with the findings that the top 1% of academically gifted individuals who attended highly selective institutions make up roughly half of various US leaders of society (Wai 2013), this suggests that high ability individuals innovate across a wide range of areas, perhaps based in part on aptitudes (both level and pattern), interests, personality, motivation, and of course their access to appropriate educational or other stimulating opportunities (Wai et al. 2010).

Jones (2016) argues that investment in developing the talents of all individuals in a nation could have positive spillovers in the form of increased patience, cooperation, and being more knowledgeable and informed. Therefore, investments in nutrition and education may have the potential to improve a wide range of outcomes. Jones and Summers (2020, p. 34) assessed the social returns to innovation, concluding that "innovation investments can credibly raise economic growth rates and extend lives, paying for their costs many times over. And because the social returns exceed the private returns, public policy has a central role, and opportunity, in unleashing these gains." Linking these economic estimates of spillover effects of broad human capital investment to Heckman (2000) payoff curves and broader literature (e.g., Lubinski and Benbow 2006, 2020) showing that fully developed talented individuals may contribute a great deal to innovation in society suggests that investing in the gifted—in particular the less advantaged—has the potential to enhance real-world problem solving and improve the rate of social returns. Admittedly: to ensure that everyone benefits requires social policies that go far beyond gifted education and tal-

ent development to address a wide range of inequalities (e.g., Blanchard and Rodrik 2021). Moreover, even when everyone benefits from innovation and advancement, some groups may benefit more than others, widening gaps that already exist (Ceci and Papierno 2005). We do not want to minimize these complex issues; our point is simply that solving major real-world problems has the potential to benefit everyone. Of course, giftedness can be put to bad uses as well as good ones; in Section 8 below, we discuss how to promote the latter applications of giftedness.

6. Companies Seek Talented People, Who Can Come from Anywhere

Investing in gifted children in the early years, especially those from disadvantaged backgrounds, can simultaneously help improve innovation and equity. However, in the US at least, gifted education appears to be a low priority in kindergarten through 12th grade (K-12) education. This is in contrast to the broader talent selection and development priority of companies worldwide—including in the US—who are desperately seeking talented individuals from around the world to improve innovation and revenue generation (Roose 2014). For example, global talent searches in the form of high-end programming competitions—Google's CodeJam, Facebook's Kaggle Recruit, or Microsoft's Code4Bill talent search in India—are useful, cost-effective screening tools for top tech companies to get the variety of talented people they need. Google's CodeJam winner in 2012 described the content of the competition as "more like mathematical work or solving logic puzzles," so something very much akin to a high-level cognitive aptitude test (Chabris and Wai 2014). Similarly, the Thiel fellows program gives $100,000 and access to a network of contacts to those who want to build things and may not need to go through the traditional sequence of schooling such as attending college (https://thielfellowship.org/, accessed on 10 June 2021). Recently, Eric and Wendy Schmidt launched the Rise program, which seeks to uncover talented youths from around the world and provide them with resources for life (Mehta 2020).

Companies may have largely focused on selecting talent later in the pipeline globally instead of investing in talent early in US K-12 education because much of the talent they are interested in (and meets company needs) comes from countries outside the US. For example, 37% of the US Nobel Prize winners from 2000–2020 in physics, chemistry, and medicine were immigrants (National Foundation for American Policy 2020). In 2016–2017, foreign students accounted for 54% of master's degrees and 44% of doctorate degrees given in STEM fields in the US (Congressional Research Service 2019), and many top companies are founded by immigrants (Wadhwa et al. 2007). Not only do these highly gifted immigrants who are educated in the K-12 systems of other countries contribute disproportionately to US innovation; they also often end up residing in the US and having children, and many of those children are highly talented individuals who may also contribute to further innovation, what Anderson (2004, p. 15) has called the multiplier effect. Historically the US has been a magnet for highly skilled individuals in search of opportunity and who have sought out US higher education, which is still among the best in the world. However, in the broader interest of solving worldwide problems there is no reason why the US will be where individuals seek to further their personal opportunities. For solving global real-world problems, the key is that top talent is provided support to innovate wherever they are or wish to live and work.

7. Lack of Development of the Gifted, Particularly among the Disadvantaged

Underdevelopment of talent is a larger problem in countries outside the US—specifically low-income, low-opportunity countries (Rosling et al. 2018). However, both the students themselves and the country or world as a whole still can benefit from investing in the relatively disadvantaged talented students within the country. This should be done not just for innovation purposes, but for the purposes of equity and seeking to ensure social mobility and that positions of leadership in US society can be accessed by talented students from low-income backgrounds and other marginalized communities, especially underrep-

resented minorities. Here we discuss the US as we are most familiar with it, but structural and systemic barriers to talent development globally are equally important to consider.

The federal K-12 investment in gifted and talented education in the US has remained at roughly 0.0002% for decades, which amounts to 1 dollar for every $500,000 spent (Wai and Worrell 2016). This lack of investment in gifted education primarily impacts public school gifted programming, which is what most talented students from poor backgrounds rely on (Peters 2021). At the same time, talented students with parents with greater resources have not been set back by this lack of funding since their parents can find ways to provide a sufficient educational dosage for them outside traditional public schools (Berner 2017). Early universal screening for gifted and talented students coupled with adequate matching of educational programming would do a great deal to help talented-but-disadvantaged students develop to their fullest and improve the likelihood they can ascend the highly competitive elite college admissions hurdles and find their way into positions of leadership in US society. At present, however, many talented-but-disadvantaged students still fall through the cracks.

The issue of *how* and *why* gifted students from some groups are less likely to be identified is complex and controversial (see e.g., Hair et al. 2015; Liu and Waller 2018, for discussion). Societal and structural inequalities including poverty lead to gaps in identification through many mechanisms and hurdles throughout the path to being identified as gifted, but the mechanism relating most to cognitive aptitudes (and thus most relevant to this article) is clear: students from disadvantaged backgrounds are less likely to undergo cognitive testing for potential gifted identification in the first place (Card and Giuliano 2016; Grissom and Redding 2016; McBee et al. 2016). For instance, as Worrell and Dixson (2018) noted, academic achievement gaps between ethnic groups in US schools are large, and given that early educational performance (e.g., grades) is often used as evidence to nominate a child for gifted evaluation, many Black and Hispanic students are less likely to ever even be given aptitude tests. At times, families play a strong role in nomination for gifted evaluation as well, and students from low-socioeconomic status (SES) homes are less likely to have parents who push for such evaluation (Calarco 2018; Grissom and Redding 2016; McBee et al. 2016). This latter mechanism may also explain why the test used for admission into New York City's selective high schools—schools known to have few Black and Hispanic students (e.g., Shapiro 2019)—is only taken by a relatively small proportion of students from those ethnic groups to begin with.

Once a student is evaluated for giftedness, the identification criteria vary widely. Traditional cognitive tests are likely to leave out an important population of gifted students. Almost all standardized tests that are used for various forms of educational selection include primarily math and verbal reasoning measures (Lakin and Wai 2020; Wai and Lakin 2020), leaving out spatial reasoning and other aptitudes. In the hierarchical model (Carroll 1993), below the general factor the three main specific aptitudes are math, verbal, and spatial in the Radex configuration (Lubinski 2004). Through this lens, Lakin and Wai (2020) estimated, based on three independent population representative samples, that over 2 million spatially talented students, who are adept at being able to visualize and rotate figures in their mind's eye and work with their hands, are currently missed in US K-12 education. Therefore, curricula are not set up to suit their strengths, and these students tend to underachieve and are more likely to develop behavioral issues (Lakin and Wai 2020). This is despite the fact that spatial reasoning has been linked to a wide range of innovation outcomes from STEM to the visual arts (Wai et al. 2009), and has been shown to be malleable (e.g., Sorby et al. 2018; Uttal et al. 2013).

8. Development of the Gifted on Multiple Dimensions

Although we emphasize aptitude testing in *selection* processes for gifted programming, the programming itself should go far beyond traditional academic skills. Regarding character education, we also suggest the cultivation of specific skills and tendencies that have been a focus of recent empirical research. Two especially neglected areas for talent

development are intellectual humility (Leary et al. 2017) and actively open-minded thinking (Baron 2019). Those two traits both involve awareness of common biases and limitations that accompany thinking, and a consequent tendency to seek and seriously consider alternative points of view. Such a tendency may help gifted students to understand that although they are highly intelligent, they should expect to make mistakes at times, and should adjust their intellectual confidence accordingly. Intellectual humility also helps gifted students to understand the importance of domain-specific knowledge when making judgments and decisions. This helps to guard against what the philosopher Nathan Ballantyne (2019) has called *epistemic trespassing*, where people with expertise in one domain make overly confident judgments far outside that domain. As academically high-achieving students become accomplished adults, they will typically develop an area of professional focus, and should carefully consider the expertise of those in other areas. Finally, intellectual humility and actively open-minded thinking both mitigate the effects of political or other ideological polarization. Rather than dismissing different perspectives, actively open-minded thinkers deliberately search for reasons why they might be wrong, and are less likely to fall prey to errors caused by biases in reasoning (Toplak et al. 2017). Interestingly, despite their openness, they are also less likely to believe fake news stories (Bronstein et al. 2019). They seem to have the best of both worlds, then—curious and tolerant of multiple viewpoints, but able to evaluate information critically when necessary.

Intellectual humility and actively open-minded thinking are especially important to cultivate in gifted children, given research showing a lack of relationship between cognitive aptitude and *myside bias* in thinking (e.g., Stanovich et al. 2013; Stanovich and West 2008). That is, brighter students are actually not substantially better than their peers at being fair and objective when evaluating evidence and argumentation, or distancing their judgment process from their prior opinions. Instead, high cognitive aptitude may only lead gifted students to be better able to rationalize and justify their beliefs, which would feed polarization rather than attenuate it. There are many studies giving guidance on how to cultivate open-minded thinking. These studies often use the umbrella term critical thinking but include core elements of open-minded thinking. For example, Parks (2015) reviewed the critical thinking literature with a particular focus on applying it to gifted education. There has been less empirical research on the teaching of intellectual humility, but Roberts (2015) suggested that teachers should model intellectual humility themselves, encourage students to explicitly describe how and what they have learned from others, and use literature to show students rich examples of intellectual humility as well as its opposite.

Because talented individuals do end up as leaders of society (Wai 2013) in various domains of influence and also hold a large amount of resources and power (Freeland 2012; Goodhart 2020; Sandel 2020), it is important to help them understand that they are fortunate to be talented to begin with. Although they have likely worked quite hard, they started their journey with cognitive and other resources that many of the less fortunate lacked. Individuals who have a head start in life should be taught not to exploit their influence or aptitudes to the disadvantage of others. Relatedly, they may have not developed the skills required to cope with failure—an experience that they may have rarely faced, instead being consistently at the head of the class and accustomed to success. Murray (2008, p. 132) argued that "No one among the gifted should be allowed to rise to a position of influence without knowing what it feels like to fail. The experience of internalized humiliation is a prerequisite for humility." The gifted can benefit from humility and wisdom. Perhaps one key to help talented students fail deliberately is entirely consonant with ensuring all students are fully if not more than sufficiently challenged and meeting their upper cognitive limits in schools through rigorous educational opportunities (Assouline et al. 2015; Wai et al. 2010). Another might be to help the talented but disadvantaged rise to positions of influence as they will have very likely internalized failure more readily in overcoming adversity. Failure may also be crucial to withstand, perhaps even collectively over time, in order to ultimately make a true scientific or other advance. For example, Harris (2021) explains that repeated unsuccessful efforts to develop an HIV vaccine was in fact a core cat-

alyst for developing the scientific know-how that has led to the development of a sequence of other vaccines that led to successfully combating COVID-19.

To further address polarization, gifted students—like all students—should be educated to value and respect different ways of thinking. In particular, it is important for the gifted 5 percent of achievers to have compassion for those who are not as gifted and who likely face many more challenges throughout their lives because they do not have this cognitive or other head start. The gifted should recognize that though they have earned some of their station in life, being a good citizen may increase their responsibility to care for the common good, given that they started on second or third base. This may lead to solving consequential real-world problems that can improve the common good.

9. Practical Implications

9.1. Identification of Gifted Students (and Really All Students) on a Developmental Continuum

First, students with high potential must be accurately identified. Research has repeatedly shown that formal assessments capture students that are missed through teacher nomination processes, and formal assessments also lead to more equitable identification rates across ethnic groups (e.g., Card and Giuliano 2016; Grissom and Redding 2016; McBee et al. 2016). Schools should therefore be universally screening students for high aptitude (Card and Giuliano 2016; Dynarski 2018), and also comparing students to others with similar opportunities to learn using local norms to further broaden the group of those identified and are ready for more challenging educational opportunities (Peters et al. 2019). Screening all students at an early age, on mathematical, verbal, and spatial reasoning, and then matching those students to the right mix or dosage of appropriate learning opportunities, can do a great deal to help develop their talents to the fullest (Wai and Lakin 2020). Testing at more than one point in time is important as well, to make room for late bloomers and to ensure educational programming is matched to short-term developmental need (Kaufman 2013). More generally, individuality is wide ranging and society should encourage multiple forms of talent and find productive ways to encourage intellectual diversity. This screening and support should apply to all students in schools, not just a somewhat arbitrarily defined set of students. As Sternberg (2020) noted, real-world problems often have features that are not found in typical intellectual and academic test items, and so we should always be open to considering new aptitude-related constructs and measures that can supplement current testing.

Assessing multiple areas of aptitude (even just the primary three mentioned— mathematical, verbal, and spatial) also helps to address concerns that gifted students who have concomitant disabilities ("twice-exceptional" students) are being neglected. For instance, if only one measure of aptitude is used, and it is heavily verbally loaded, a gifted student with autism spectrum disorder may not be properly identified (see Dawson et al. 2007). This does not mean that the standards for giftedness or disability identification should vary from student to student (see Lovett 2013, for some of the problems with such approaches), only that when selecting assessment measures, different areas of aptitude and disability should be considered.

9.2. The Imperative of Gifted Support

Second, formal gifted education should be available in far more school districts; it should be a very rare school where a student cannot access some type of appropriate talent development. Additionally, programming for supporting gifted students comes in a variety of forms and may not be limited to public schools (Berner 2017). For instance, acceleration involves leading high-aptitude learners through academic material at faster rates than their peers (Assouline et al. 2015); this broad class of interventions has relatively clear benefits for academic skill development without negative socioemotional effects (Bernstein et al. 2020; Steenbergen-Hu and Moon 2011). Enrichment strategies instead provide additional information on topics covered in class, exposing academically gifted students to specific content domains of knowledge in greater depth; this intervention is associated with even greater

gains in academic skills, as well as improved socioemotional development (Kim 2016). Both strategies address the needs of the academically achieving 5 percent, replacing potentially redundant content with more challenging and stimulating work. Enrichment programs can also involve introducing high-aptitude learners to real-world problems that they may later choose to investigate in greater depth. In addition, both enrichment and acceleration can expose gifted students to quite difficult material, teaching the coping skills and self-awareness that come with the experience of making mistakes and struggling with conceptual complexity, and ultimately learning to fail productively.

9.3. An Environment Supporting Significant Intellectual Accomplishment

Finally, there needs to be a valuing and respect and even celebration for high accomplishments in cognitive and academic domains of expertise. Optimally, this would happen in the larger culture, but at the very least, schools should be settings where high-aptitude students are motivated to achieve appropriately ambitious goals through incentives, including attention, recognition, and praise from educational professionals and their peers. Gagné (2018) emphasized the importance of personal excellence goals in talent development, but without some extrinsic reinforcers, gifted students are apt to fall into the common path of underachievement (Siegle 2018).

10. Conclusions

Improving the talent development of the top 5 percent of gifted students globally will improve the likelihood of solving multiple (including presently unforeseen) consequential real-world problems in the future that can promote the common good and enhance our standard of living. Fully developing the talent of low-income and disadvantaged students is crucially important for equity reasons such as social mobility and will also improve innovation, injecting more diverse talent that has likely overcome more failures and developed character in positions of leadership. Investing in all individuals can also have numerous, broad beneficial spillover effects such as social returns. Finally, apart from the benefit to society of fully developed gifted students, the realization of one's personal and intellectual capacities is important to support for *all* students, and for this reason alone we should be ensuring we help the most brilliant students from every walk of life have the opportunity to become their very best.

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A Model of How Shifting Intelligence Drives Social Movements

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Abstract: Based on the theory of social change, cultural evolution, and human development, we propose a mechanism whereby increased danger in society causes predictable shifts in valued forms of intelligence: 1. Practical intelligence rises in value relative to abstract intelligence; and 2. social intelligence shifts from measuring how well individuals can negotiate the social world to achieve their personal aims to measuring how well they can do so to achieve group aims. We document these shifts during the COVID-19 pandemic and argue that they led to an increase in the size and strength of social movements.

Keywords: intelligence; social movements; theory of social change, cultural evolution, and human development; social intelligence; practical intelligence; abstract intelligence; COVID-19; cultural evolution; adaptive intelligence; George Floyd protests

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1. Introduction

Based on the theory of social change, cultural evolution, and human development (Evers et al. 2021; Greenfield 2009, 2016, 2018; Greenfield et al. 2021), we propose a mechanism whereby increased danger in society (as indicated by mortality rate and resource scarcity), plus smaller social groupings, trigger evolutionarily conditioned shifts toward the forms of intelligence valued in the small-scale subsistence ecologies omnipresent in earlier human history. Under these conditions, there are two shifts in valued forms of intelligence: 1. *practical intelligence* rises in value relative to *abstract intelligence*; and 2. social intelligence shifts from measuring how well individuals can negotiate the social world to achieve their personal aims to how well they can negotiate the social world to achieve group aims. We document these shifts during the pandemic as society became more dangerous and social units became smaller. We then argue that these shifts in the valued forms of intelligence have led to an increase in the size and strength of social movements. Lastly, we conclude that, on average, throughout human history, these psychological responses likely contributed to humankind's success by creating the most adaptive society for each set of changing environmental conditions. However, since humans seem to employ adaptive intelligence at the community level, one community furthering its aims can cause harm to another community.

2. Theory of Social Change, Cultural Evolution, and Human Development

The theory of social change, cultural evolution, and human development is a predictive model of how changing sociodemographic variables shift psychological and behavioral variables consistent with archetypal ecological variables (Evers et al. 2021; Greenfield 2009, 2016, 2018; Greenfield et al. 2021). Sociodemographic variables, all of which induce value changes, include formal education, urbanization, and communication technologies (e.g., Manago 2012; Weinstock et al. 2014). The relevant sociodemographic variables in the case of COVID are mortality rate, resource scarcity, and community size. The two ecological archetypes are subsistence and commercial ecologies. The former is associated

with a collectivistic value system, and the latter with an individualistic value system. Rather than affecting values directly, ecological shifts can also induce behavior change, which subsequently leads to value change, as occurred in a Maya village in Chiapas, Mexico (Greenfield 2004).

Subsistence ecologies are characterized by small villages, short life expectancies, low material resources, collectivism, and basic survival activities; people produce their own food, shelter, and clothing. Most relevant to our argument, members of subsistence ecologies prioritize practical intelligence over abstract intelligence and measure social intelligence by how well an individual can negotiate the social world to benefit the collective (family and community) rather than the individual (Greenfield 2019). Early in human history, these two forms of intelligence were successful adaptations for living in small-scale ecologies with high mortality rates and scarce resources.

In commercial ecologies (a product of cultural evolution) most people live in large-scale urban environments; people have substantially longer life expectancies, access to more material resources, and purchase rather than produce food, shelter, and clothing. Most relevant to our argument, people living in a commercial environment prioritize abstract intelligence over practical intelligence; they measure social intelligence by how well an individual can negotiate the social world to benefit the individual rather than the collective (Greenfield 2019). These forms of intelligence are not mutually exclusive contrasts but are relative prioritizations of intelligence components.

Contrary to the conventional construct of intelligence as measured by IQ, we are taking intelligence as a multi-faceted construct consisting of an amalgamation of different sub-constructs that include ability, knowledge, character, wisdom, values, and skills. Our concept of intelligence also subsumes underlying motives or aims which employ these subconstructs.

3. The Pandemic Creates a Shift in Valued Forms of Intelligence

Our research has shown that, as COVID-19 increased mortality rates in the United States, made resources scarcer, and greatly reduced the scale of people's social world, values and behavior shifted toward the values and behavior characteristic of subsistence ecologies (Evers et al. 2021; Greenfield et al. 2021), albeit in a technologically enhanced environment (Brown and Greenfield 2021). Since the pandemic made the environment radically more dangerous and people's social world much smaller in a very short period of time, it served as a powerful natural experiment.

High mortality rates and small social units are characteristics of a subsistence village ecology. During the coronavirus pandemic, both of these environmental features increased greatly in a sudden fashion. Under stay-at-home orders, people were interacting with a smaller number of other people. At the same time, many were experiencing increased danger from COVID-19. Conditions were moving toward those found in subsistence ecologies.

Our theory predicted (and we found) that greater survival concerns (e.g., thinking about one's own mortality) and more days spent observing stay-at-home rules would lead to increased subsistence activities and values, more collectivism, greater family interdependence, and parents socializing children to contribute to family maintenance. We tested the theory in the United States with both a large-scale survey and a massive analysis of internet behavior (Evers et al. 2021; Greenfield et al. 2021).

Most relevant to forms of intelligence, subsistence activities (e.g., growing food) are a manifestation of practical intelligence; the frequency of these activities rose during the pandemic both online and in the real world. Shifts in values and new directions in children's socialization supported the development of practical intelligence. During the pandemic, subsistence values (e.g., conserving resources) increased and parents expected children to contribute more to household subsistence with practical skills (e.g., helping prepare family meals). This shift in parent expectations not only developed children's practical intelligence; contributing to family subsistence may have also developed their *collectively oriented social intelligence.* Increases during the pandemic of collectivistic values (sacrificing,

sharing, helping, and giving), as well as increased family interdependence (participation in family activities, mutual help to family members) were a manifestation in both values and behavior of the increased importance of collectively oriented social intelligence.

These findings represent a shift in American psychology and behavior toward that typical of the small-scale subsistence villages, prevalent at an earlier point in human history. Since we found "parallel adaptations occurring in only a few weeks during stay-at-home and the pandemic, we suggest that the human species is geared for the same adaptations when these conditions reappear" (Greenfield et al. 2021). However, societies where there was, even before the pandemic, greater respect for authority, a characteristic associated with subsistence ecologies, had an easier time responding to the pandemic with behavioral restrictions than societies, such as the United States, in which the value of individual freedom was greater (Gelfand 2020).

4. The History of Practical Intelligence in the Field of Psychology

The concept of practical intelligence emerged in the 1940s with the invention of situational judgment tests to assess managerial potential and came to the forefront with Robert Sternberg's triarchic theory of intelligence and subsequent theory of successful intelligence (McDaniel and Whetzel 2005; Sternberg 1985, 1988, 1997). Practical intelligence has been characterized as "street smarts", "common sense", or the "cognitive underpinning of everyday function" (Hedlund 2020, p. 737; Yalon-Chamovitz and Greenspan 2005, p. 220; Nunes et al. 1993). More generally, practical intelligence refers to the ability to solve the problems individuals encounter in everyday life (Hedlund 2020; Sternberg and Grigorenko 2000). It requires employing solutions to problems that involve the actual doing of something and can be contrasted to abstract intelligence, employing solutions that concern theory and ideas.

Practical intelligence is a form of intelligence that evolved to facilitate the functioning and survival of subsistence communities (Greenfield 2019). Subsistence activities require the development of practical intelligence. However, practical intelligence is usually not prioritized in our technological environment, where the emphasis is on abstract intelligence. However, as noted earlier, during the pandemic, there was a significant rise in the exercise of practical intelligence (Evers et al. 2021; Greenfield et al. 2021). This shift was stimulated by increased mortality salience brought about by the all-too-real mortality threat of the pandemic and the narrowing of the social world to household and immediate neighbors due to stay-at-home orders (Greenfield et al. 2021). Activities that increased during the pandemic, such as baking bread or home repair (Evers et al. 2021; Greenfield et al. 2021) require practical intelligence, adapted to real-world contexts, as Alexander Luria (1976) pointed out decades ago.

The different intelligences are suited to the perceived urgency with which a problem needs to be solved. Practical intelligence is better suited to high levels of immediacy, and abstract intelligence is better suited to lower levels of immediacy. For this reason, in times of danger when humans face an immediate threat, they employ more practical intelligence than abstract intelligence and vice versa under safer conditions. This ability to shift the focus of intelligence in order to adapt to different conditions is a basic secret to the evolutionary success of human beings.

5. Types of Social Intelligence in the Field of Psychology

The modern concept of social intelligence has its origin in E.L. Thorndike's division of intelligence into three different abilities: the ability to comprehend and manipulate ideas (abstract intelligence), concrete objects (mechanical intelligence), and people (social intelligence) (Thorndike and Stein 1937). Thorndike wrote: "By social intelligence is meant the ability to understand and manage men and women, boys and girls—to act wisely in human relations." Since Thorndike's classical formulation of social intelligence, it has been measured and defined in many ways, and two principal perspectives emerged (Kihlstrom and Cantor 2000). The first perspective was social intelligence as an ability, embodied by

Thorndike's definition above and subsequently espoused in different notable iterations by Guilford (1967), Gardner (1983), and Goleman (1995). Later, Kihlstrom and Cantor offered a second perspective, "The Knowledge View of Social Intelligence", where social intelligence refers to an "individual's fund of knowledge about the social world", mediated by the individual's general cognitive processes (Kihlstrom and Cantor 2000, p. 573; 1989; Cantor and Kihlstrom 1987, 1989).

However, these definitions assess small differences between individuals in today's developed Western societies. This measurement orientation is evident in the individualistic lens through which social intelligence is defined both by Thorndike and Kihlstrom/Cantor: intelligence as an ability measures how well an individual can manipulate others for their aims. Intelligence as knowledge differs only slightly since it says that social intelligence is an individual's store of specific knowledge about the social world transformed into behavior by general cognitive ability. Whether someone has social intelligence, defined as an ability or a fund of knowledge, their intelligence is measured by how well they can manipulate others for their own aims as an individual. This measure is most relevant for current Western psychology since the status quo of Western thinking and, as a result, psychology as a discipline, is to use the individual as the basic unit of society.

However, in this essay, our interest is in fundamental deviations from the status quo of Western thinking, shifts from the psychology and behavior of modern ecologies toward the psychology and behavior of the subsistence ecologies that defined an earlier era of human history and exist in pockets of today's world. A fundamental difference between subsistence ecologies and ours is that, in the former, the welfare of the community supersedes that of the individual.

Outside the Western definitions of social intelligence as a measure of ability or a fund of knowledge, an entirely different conception has arisen through studying how subsistence ecologies think about what we would refer to as "social intelligence." Mundy-Castle's definition of social intelligence originated in his long-term experience with African cultures. He defined social intelligence to include character, wisdom, and collectivistic values, and emphasized that social intelligence incorporated technical skills insofar as they contributed to the community (Mundy-Castle 1974). Similarly, Dasen, studying a Baoulé village in Ivory Coast, emphasized that the Baoulé concept of intelligence, *n'glouèlê,* integrates cognitive and social skills, as do many other African concepts of intelligence (Dasen 2011). Indeed, the most central (in the sense of agreed upon) attribute for intelligent children listed by Baoulé farmers was "readiness to carry out tasks in the service of the family and the community", a social quality (Dasen 1984, p. 426).

Lest one think that collectively oriented social intelligence is not suited to measurement, we note that a Pakistani team psychometrized a closely related concept of social intelligence, developing and validating a social intelligence scale in a sample of Pakistani university students (Habib et al. 2013). Their factor analysis revealed empathy, a key quality in collectively oriented social intelligence. as a principal component of social intelligence, a quality that had been declining in U.S. culture for decades (Konrath et al. 2011).

For our analysis, we distinguish the social intelligence of modern commercial ecologies from subsistence ecologies by the end goal. Whether we define social intelligence as a measure of ability or fund of knowledge, the social intelligence of modern commercial ecologies furthers the individual's aims, whereas the social intelligence of subsistence ecologies furthers the collective's aims. We connect social intelligence in subsistence ecologies to care for a broader community, not just oneself, and the willingness to make sacrifices for others. A rise in the social intelligence important in subsistence ecologies would increase someone's motivation to care more about and make sacrifices for their broader community. Our thesis is that the rising value of this collectivistic form of social intelligence, as well as the increased value placed on practical intelligence, paved the way for large-scale social movements during the pandemic.

6. Shifts in Valued Forms of Intelligence Prime Americans for Social Movements

Our thesis is that the augmented value of practical intelligence and collectivistically oriented social intelligence resulted in a massive increase in the desire to solve problems that faced communities and to solve them using real-world action. This is the broad-strokes definition of a social movement. Our evidence is that the pandemic witnessed a number of social movements of unprecedented size and strength. In a relatively short period of eight months, three movements spanning ideology and form shook the country. These movements were all similar in that they were expressed through employing solutions that involved the actual doing of something (practical intelligence) and, in all three cases, their aim was to benefit a community (collectively oriented social intelligence). However, each movement served the goals of a different community, thus contributing evidence to the generality of the theory. When environmental danger increases, it shifts intelligences to prime communities to enact social movements, and the shift in valued intelligence implies a shift in values. However, social movements can still occur under other conditions.

Interestingly, despite these proclivities having developed in pre-technology communities, we see them play out in our technologically enhanced environment, a factor that strengthened all of the social movements. In fact, in our increasingly tech-enabled world, the internet is forming communities along unprecedented lines and creating ingroups based on various similarities, whereas, in the past, primarily geographic and ethnic similarities defined communities. Today, the internet can align like-minded folks and place them into information silos, which further entrench their allegiance to their community and strengthen their beliefs in their communities' ideologies.

However, there was also increased interaction within small neighborhood units during the pandemic as geospatial research using cellphone data shows: the number of COVID-19 cases was correlated with increases in neighborhood isolation a week later. Additionally, places with larger populations, more public transportation use, and greater racial and ethnic segregation had larger increases in neighborhood isolation during 2020 (Marlow et al. 2021). Both the kind of communities that formed earlier in human history and those that have developed most recently grew stronger.

7. The George Floyd Protests

Incited by George Floyd's death in police custody, the George Floyd Black Lives Matter protests became the "largest movement in U.S. History", with an estimated 15 to 26 million adults taking to the streets to demonstrate (Buchanan et al. 2020). George Floyd was not the first black individual to be killed by the police or even to have their murder filmed, so why did his death in particular cause a cultural movement of unprecedented scale? Why did the largest social movement in U.S. history occur during the height of a deadly pandemic, which threatened Americans with the very real possibility of catching an illness that was ravaging the country around them?

Our theory makes the unlikely timing of this protest movement of unprecedented scale understandable. It posits that the dramatic increase in ecological danger increased collectively oriented social intelligence, priming people to want to solve issues that faced their community. The dramatic increases in the mindshare of "sacrifice", "share", "help", and "give" observed in our online analyses (Evers et al. 2021) may have primed people to be more inclined to set aside their daily commitments, forget their hesitations to civil disobedience, and lessen the extent of their self-protective coronavirus measures to improve the welfare of the Black individuals that they viewed as members of their community.

Based on Reny and Newman (2021), it seems that the community driving the George Floyd protests was low-prejudice and politically-liberal Americans. Unlike prior Black Lives Matter protests, which were majority black and could be interpreted as individualistic responses to bettering one's own welfare, almost 95% of the American counties that participated in the recent Black Lives Matter protest, were majority white, indicating an altruistic desire to help disenfranchised members of one's community (Buchanan et al. 2020). Such a community did not exist in geographic space; it was formed virtually by means of the

internet. This rise in altruistic action reflects an increased value placed on collectivistic components of social intelligence. At the same time, the rise in practical intelligence documented in our studies of the pandemic was expressed by practical action on the streets rather than more abstract virtual action online.

8. 2020 United States Presidential Election

Five months after the Black Lives Matter movement, an unprecedented social movement driven by two very different communities occurred. The 2020 United States presidential election on 3 November 2020, witnessed the highest voter turnout by percentage since 1900, with this voting spike occurring across both Democratic-leaning and Republic-leaning demographics (Park 2020; Frey 2021). The unusually high turnout by both Democrats and Republicans reflects the divided political landscape of America. As predicted by our theory, members of both parties felt a significantly increased desire to solve the problems facing their respective community, that is, members of their political party, and expressed that desire through the real-world solution of voting.

9. 2021 United States Capitol Attack

Two months after the election, on 6 January 2021, the United States Capitol was violently attacked by a mob of Donald Trump supporters, who successfully disrupted the planned counting of electoral votes that would formalize Joe Biden's victory (Luke 2021; Reeves et al. 2021). The attack resulted in American insurrectionists mounting the first mass breach of the U.S. Capitol since the War of 1812 (Dilanian and Collins 2021; Lakritz 2021). Hundreds of Donald Trump supporters felt a significantly increased desire to solve problems facing their community; in this case the community was right-wing extremists, again very much a product of an internet information silo. They integrated this manifestation of social intelligence with the practical intelligence necessary to organize an attack on the Capitol to disrupt the counting of the electoral votes.

10. Conclusions

10.1. Implications for Social Change

When we initially found that residents of the United States valued practical intelligence and collectively oriented social intelligence significantly more during the pandemic, our interpretation was positive (Evers et al. 2021; Greenfield et al. 2021). We predicted that these shifts in valued intelligence would optimize the creation of a more cohesive and empathetic society, thus reversing the documented historical decline in empathy (Konrath et al. 2011) and communitarian activity (Putnam 2000). At the simplest level, we thought people would care more about other people and employ practical methods to realize their desired outcomes. At that point in the pandemic, the Black Lives Matter movement was the only social movement of unprecedented size and strength that had occurred, so, being low-prejudice, liberal Americans ourselves, we concluded that collectivistic goals combined with real-world action lend themselves particularly well to social progress. When the other two unprecedented movements occurred, it threw into question our idea of linear social progress. Today's society is much larger than the social units of early human history. For most of cultural history, the social unit of reference was a small village in which everyone knew each other. However, the United States has a population of over 300 million (United States Census Bureau 2021). Our prediction that the shifts in valued intelligences would create linear social progress was wrong since social progress is subjective, and the functional collective unit is not the United States but subgroups within the country. People identify with their communities and, as the world gets more dangerous and protective responses kick in, those ingroups become even more cohesive. It seems clear that the shifts in valued intelligence created by increased mortality rate, resource scarcity, and a narrowing of the social world do not lead to any particular direction of social change but to stronger and larger social movements that have more to do with a specific community's desired direction of social change than to the country as a whole. Hence, the result can and

has been social movements going in opposite directions. In a complex society, collectively solving one community's social problems may easily be perceived to create greater social problems for a different community.

10.2. How Lasting Are These Pandemic-Induced Intelligence Shifts?

As observed by Evers et al. (2021) and Greenfield et al. (2021), the pandemic caused humans to adapt very quickly. America witnessed a massive shift in psychology and behavior toward an earlier time of human history within a couple of months. Therefore, humans will likely adapt similarly quickly in the opposite direction when the conditions reverse.

10.3. The Adaptiveness of Shifting Intelligence

Intelligence is traditionally conceptualized as a general factor in a psychometrically-based hierarchical intelligence model and measured by standardized tests such as the IQ test (Sternberg 2019). Early psychometricians designed the IQ test to predict real-world performance, and the tests were considered valuable to the extent that they predicted that performance (Sternberg 2021). However, a false turnaround has occurred over time where the IQ or score on a similar standardized test of intelligence has become more important than whatever the tests predict. While almost all definitions of intelligence agree on one thing, that intelligence involves the ability to adapt to the environment, the current understanding of "intelligence" refers to a construct that is, at best, vaguely related to intelligence as adaptation (Sternberg 2019). Sternberg rejects the current understanding of intelligence as measured by IQ and similar measures and instead believes that the measure of intelligence should be its adaptiveness in an evolutionary sense (Sternberg 2019, 2021). Human psychological processes and behavior that are "adaptively intelligent" further the biological interests of survival. Sternberg defines adaptive intelligence in the context of success at broad adaptation. Broad adaptation includes narrow adaptation, a "process by which an animal or plant species becomes fitted to its environment; it is the result of natural selection's acting upon heritable variation" (Gittleman 2018) along with "changing the environment to fit oneself (shaping the environment) and finding or creating new environments as needed (selecting environments)" (Sternberg 2019).

By this definition, would the observed shifts in intelligence be considered "adaptively intelligent?" Yes, but in a slightly different fashion than Sternberg's model of adaptive intelligence. First, it appears that the shifts in intelligence observed during the pandemic occurred with the community as the basic social unit and furthered the aims of the community, which may or may not have aligned with the aims of the entire species. However, it is unnatural for humans to think on such a large level as optimizing the survival of the whole human species when we have been hard-wired through evolutionary history to operate on the level of a small village. For this reason, it seems people have a hard time making progress against the existential threats facing humanity, namely climate change, nuclear weapons, and pollution, which Sternberg argues would be some of the best measures for adaptive intelligence (Sternberg 2019). We would say that for better or for worse, evolution did not condition humans for those sorts of threats. They are too big and too distant. Instead, it seems that humans are much better suited to be adaptively intelligent on the level of their community or ingroup. We would posit that intelligence is a community, not an individual or species adaptation.

It is intuitively adaptive that when the world gets more dangerous, the rising value of collectively oriented social intelligence increases motivation to care more about and further the aims of one's tribe, and the rising value of practical intelligence increases the motivation to solve the pressing issues facing their tribe using practical solutions. While this banding together as a community and solving the community's pressing issues is generally a successful evolutionary strategy, it requires that the community solve the correct issues with the correct solutions. For these shifts in intelligence to be adaptively intelligent, they would have to focus on solving survival problems, which would mean that the community would have to care enough about the survival problems and address them

with a correct solution. While, on average, humans have been able to do this successfully, that does not mean that the evolutionarily fit decision is always evident.

For example, one might say that refusing to wear masks caused thousands or hundreds of thousands of deaths. However, this is a matter about which different communities, split down partisan, gender, and racial lines, hold differing ideologies (Brenan 2020). One's opinion on this issue says more about the community they belong to than the objective adaptivity of mask-wearing since both the communities that wear masks and those that refuse to can rationalize their behavior using the language of survival. Mask wearers can point to research showing that masks effectively decrease the spread of air-borne COVID-19 particles (Union-Bulletin Editorial Board 2020). In contrast, those who refuse to wear masks can point to research showing that wearing masks can lead to a dangerous false sense of security, cause other health risks, worsen the burden of COVID-19 on an individual, and even increase the spread of COVID-19 through inappropriate mask use (Lazzarino 2020).

Humans can never truly know the actions to execute that will best ensure the survival of their community. Therefore, they act on ideologies since, by definition, an ideology is the system of ideas held by a community. We have examples to show that when people come under threat, they shift these specific intelligences, resulting in furthering the collective's aims through practical measures. However, it seems that the aims of the collective that this adaptation furthers have a higher correlation with the centrality to the community's ideology than the objective adaptiveness of these aims as defined by survival. That said, one can imagine that pressing survival threats in forms that evolution conditioned humans for (not the massive, distant threats of climate change, nuclear weapons, and pollution) would become central to a community's ideology and be solved. Therefore, it appears that humans use a heuristic to reason by proxy that the most adaptive path is to execute their community's ideology. Does this mean that ideology trumps intelligence? No. When the world gets more dangerous, intelligence becomes the vehicle for enacting and furthering ideology. Why might this be evolutionarily fit? Since in dangerous times, individuals banding together as a collective to enact solutions in line with their community's ideology is a safer and faster bet for problem solving than if the individuals were to innovate unique solutions.

10.4. Implications for Cultural Evolution

Different intelligences are adapted to different ecologies. For example, in pre-COVID times, abstract intelligence was valued over practical intelligence and *individually oriented social intelligence* was valued over collectively oriented social intelligence in the United States and other commercial ecologies (Mundy-Castle 1974; Greenfield 2019). These forms of intelligence are perfect for making technological and scientific progress. As evinced by rising economic inequality and other social problems, this progress came at the cost of having an increasingly less empathetic and community-minded society (Konrath et al. 2011; Putnam 2000). As valued intelligences shift, based on changing ecological conditions, there will always be a trade-off between the psychological conditions that best push humanity into the future through technological and scientific advances and the conditions that strengthen social bonds and lead to solving social problems.

This dynamic interplay between valuing community welfare and valuing technological progress is, in our view, a permanent part of human history. We hypothesize an evolved tendency in social and cultural evolution to favor groups that strengthen their social units in times of danger and instability but push forward with advances in technology and abstract thinking in times of safety and stability. If corroborated by continuing research, the balance between these opposing forces would even appear to be responsible for much of humankind's evolutionary success.

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Beyond IQ: The Importance of Metacognition for the Promotion of Global Wellbeing

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Abstract: Global policy makers increasingly adopt subjective wellbeing as a framework within which to measure and address human development challenges, including policies to mitigate consequential societal problems. In this review, we take a systems-level perspective to assemble evidence from studies of wellbeing, of collective intelligence, and of metacognition and argue for a virtuous cycle for health promotion in which the increased collective intelligence of groups: (1) enhances the ability of such groups to address consequential societal problems; (2) promotes the wellbeing of societies and the individual wellbeing of people within groups; and, finally, (3) enables prosocial actions that further promote collective problem-solving and global wellbeing. Notably, evidence demonstrates that effective collaboration and teamwork largely depend on social skills for metacognitive awareness—the capacity to evaluate and control our own mental processes in the service of social problem-solving. Yet, despite their importance, metacognitive skills may not be well-captured by measures of general intelligence. These skills have instead been the focus of decades of research in the psychology of human judgment and decision-making. This literature provides well-validated tests of metacognitive awareness and demonstrates that the capacity to use analysis and deliberation to evaluate intuitive responses is an important source of individual differences in decision-making. Research in network neuroscience further elucidates the topology and dynamics of brain networks that enable metacognitive awareness, providing key targets for intervention. As such, we further discuss emerging scientific interventions to enhance metacognitive skills (e.g., based on mindfulness meditation, and physical activity and aerobic fitness), and how such interventions may catalyze the virtuous cycle to improve collective intelligence, societal problem-solving, and global wellbeing.

Keywords: collective intelligence; metacognition; wellbeing

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1. Collective Intelligence, Metacognition, and Wellbeing

Collective intelligence, metacognition, and wellbeing are three constructs that have developed largely independently from one another in psychology and allied fields, which we review here. Yet, emerging evidence indicates there are potentially powerful relationships among them that can be leveraged to catalyze collective problem-solving at a systems level to address consequential societal troubles such as the coronavirus pandemic, systemic racism, and poverty. In particular, social problem-solving is largely driven by social engagement (Mao 2016) and the collective intelligence of a community (Tovey 2015; Malone and Woolley 2020), which itself depends on effective collaboration and teamwork due to social skills from metacognitive awareness (Gupta and Woolley 2020). Further, social problem-solving can equitably promote public wellbeing, which may be necessary for promoting individual wellbeing (Lambert et al. 2020) and in turn lead to people that are more socially engaged (Mehl et al. 2010; Richards and Huppert 2011). Here we argue

that scientific interventions to enhance metacognitive awareness may improve collective intelligence, social problem-solving, and global wellbeing.

Global policy makers increasingly adopt subjective wellbeing as a framework within which to measure and address human development challenges, extending their traditional focus from material wellbeing and economic development to include the impact policies have on how people think and feel about their lives (Dolan and White 2007). Further, there is growing agreement among scientists, economists, and policy experts that the gross domestic product (GDP) should no longer be a primary performance indicator for national prosperity. The World Happiness Report (WHR) has garnered attention for its national happiness rankings; it assesses wellbeing using the Cantril Self-Anchoring Striving Scale (Cantril 1965), also called Cantril's Ladder, which rates respondents on their current and future perceived quality or satisfaction with life. Yet, as captured in the United Nations 2030 Sustainable Development Goals (SDGs), an emerging global agenda for development is recognizing the coupling of social, environmental, and economic dynamics and in particular, the interconnectedness of several dimensions of human and ecosystem wellbeing (Fioramonti et al. 2019). Moreover, the science of wellbeing is starting to reflect a richer view of wellbeing than life satisfaction alone by including hedonic and eudaemonic facets of wellbeing, social wellbeing, as well as the role of culture, community, nature, and governance (Lambert et al. 2020). Assessment tools beyond Cantril's Ladder that draw not just on psychology, but also neighboring fields such as organizational design, health, education, and economics, are being developed for this broader conception of wellbeing.

Given that subjective wellbeing in this broader conception is not only an individual consideration but is intertwined with social and environmental life, it follows that equitably promoting public wellbeing is necessary for promoting individual wellbeing. Quite interestingly, equality not just of income but also of life satisfaction is associated with higher average subjective wellbeing in countries around the world (Diener and Tay 2015). Further, the positive impact of income on subjective wellbeing is greater in more equal societies (Ng and Diener 2019). Due to the positively correlated relationships between life satisfaction and subjective wellbeing as well as between income and subjective wellbeing, we can therefore infer that subjective wellbeing is not a conserved, extensive quantity like energy or mass, but actually increases in total as it is equalized in societies. This indicates that redistribution is not a zero-sum activity.

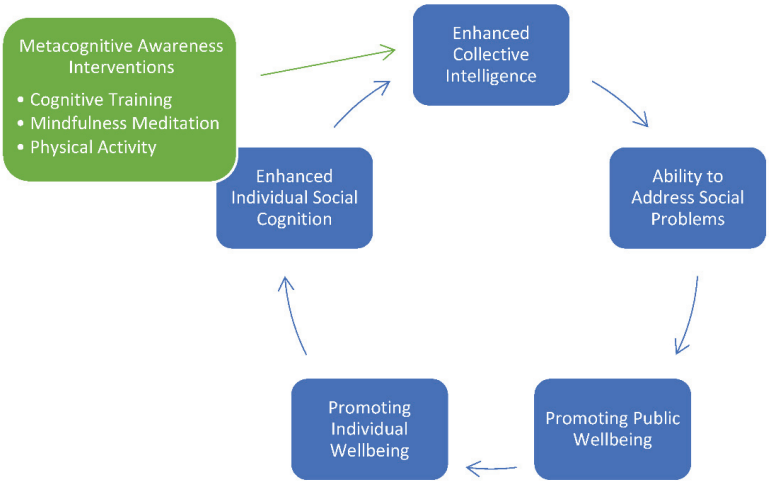
It further follows that public wellbeing is inextricably linked with consequential societal problems such as the coronavirus pandemic, systemic racism, and poverty. Public wellbeing can be promoted through collective action on social determinants of wellbeing (Fisher 2019), especially since a key driver of wellbeing is the capacity to distribute and share the cognitive, social, and economic demands of life, providing a powerful mechanism for mitigating loss and the effects of adversity.

Evidence demonstrates that people with greater individual wellbeing are more likely to show compassion and empathy (Shanafelt et al. 2005; Nelson 2009; Rand et al. 2015), make ethical decisions (James and Chymis 2004; Fernando and Chowdhury 2010), live healthier and longer lives (Wiest et al. 2011; Boehm and Kubzansky 2012), and perhaps most importantly for our discussion, be socially engaged (Mehl et al. 2010; Richards and Huppert 2011) and perform prosocial behavior (Son and Wilson 2012; Yang et al. 2017).

At the same time, recent findings suggest that addressing consequential societal problems and enhancing prosperity are largely driven by social problem-solving and the collective intelligence of a community (Tovey 2015; Malone and Woolley 2020), rather than the individual intelligence of community members. Contemporary methods to enhance collective intelligence have focused on the distribution and processing of knowledge within a social network, as measured by transactive memory and attentional systems (Gupta and Woolley 2020). Notably, the collective intelligence of a group is strongly associated with abilities such as emotional intelligence and theory of mind of group members (Woolley et al. 2010). Further, effective collaboration and teamwork largely depend on social skills for

metacognitive awareness (Gupta and Woolley 2020), the capacity to evaluate and control our own mental processes in the service of social problem-solving.

To summarize the logic that emerges from our review, we see a virtuous cycle for health promotion in which the increased collective intelligence of groups: (1) enhances the ability of such groups to address consequential societal problems; (2) promotes the wellbeing of societies and the individual wellbeing of people within groups; and, finally, (3) enables prosocial actions that further promote collective problem-solving and global wellbeing.



Is it possible to accelerate this virtuous cycle and enhance global wellbeing through science-based interventions that focus on particular metacognitive abilities, which have known neural correlates in brain networks?

2. Construct Validity

By analogy with the individual intelligence factor *g*, Woolley et al. (2010) defined a group's *collective intelligence* (*c*) as the general ability of the group to perform a wide variety of tasks. From a psychometric perspective, *c* emerges when the ability of a group to perform one task is correlated with that group's ability to perform a wide range of other tasks. This kind of collective intelligence is a property of the group itself, not just the individuals in it. Although the individual intelligence factors of group members may play a role in collective intelligence (Bates and Gupta 2017), a meta-analysis that examined 22 studies, with 5279 individuals comprising 1356 groups, showed that *c* is predicted by the proportion of women in the group, mediated by average social perceptiveness of group members, and that it is validated in the sense of predicting performance on various out-of-sample criterion tasks (Riedl et al. 2021). Yet, *c* is not nearly as well-validated as *g* (Coyle 2021).

Metacognitive awareness, with a key dimension of metacognitive knowledge, is defined as beliefs about one's own mental states and processes as well as beliefs about those of other people (Jost et al. 1998). Aptitude in these specific metacognitive skills is the focus of our analysis. There is some agreement on the general theoretical structure of metacognition, which has informed the development of the Metacognitive Awareness Inventory (MAI), a commonly used instrument for its measurement (Schraw and Dennison 1994). Although self-report instruments such as MAI may raise validity concerns, it is widely used in both research and practice; further refinements show between-group and time invariance (Harrison and Vallin 2018).

As noted above, *subjective wellbeing* is defined as how people experience and evaluate their lives, usually measured through questionnaires that have been well-validated using large-scale studies (Nima et al. 2020). An example instrument is the Satisfaction With Life

Scale (Pavot and Diener 2008), which has been validated and widely used. Wellbeing is increasingly being constructed to also include hedonic and eudaemonic facets of wellbeing, social wellbeing, as well as the role of culture, community, nature, and governance (Lambert et al. 2020). This validity of this broader construct of subjective wellbeing is still under investigation (Pancheva et al. 2021).

3. Interventions to Improve Wellbeing via Improved Metacognitive Skills

Despite their importance for collective intelligence (Gupta and Woolley 2020) and wellbeing (Kiaei and Reio 2014), metacognitive skills are not typically captured by measures of general intelligence (and are in fact weakly associated with intelligence (Ohtani and Hisasaka 2018)). These skills have instead been the focus of research in educational psychology and the psychology of human judgment and decision-making (Koriat 2015). This literature provides well-validated tests of metacognitive awareness (Schraw and Dennison 1994) and demonstrates that the capacity to use analysis and deliberation to evaluate intuitive responses is an important source of individual differences in decision-making (Kleitman et al. 2019). Moreover, this literature demonstrates that metacognitive training aids decision-making (Batha and Carroll 2007).

Research in network neuroscience further elucidates the topology and dynamics of brain networks that enable metacognitive awareness, providing key targets for intervention (Paul et al. 2015). Evidence indicates that the precuneus has differential connectivity within the default mode network of the brain across individuals' lifespans (Yang et al. 2014) and has specialized roles in self-related cognition and awareness (Philippi et al. 2012; Whitfield-Gabrieli et al. 2011). These attributes of the precuneus suggest it may be linked with over/underconfidence in decision-making or other metacognitive abilities. In our recent work, we collected resting-state fMRI data (n = 304) to perform connectome-wide association to characterize individual differences in decision-making competence, identifying regions within the frontal, parietal, temporal, and occipital cortex that demonstrated significant associations (Talukdar et al. 2018). In assessing whether functional interactions between brain regions sensitive to decision-making competence and particular intrinsic connectivity networks (ICNs) were predictive of specific facets of decision-making, we further found individual differences in specific facets of decision-making competence are mediated by ICNs that support executive, social, and perceptual processes. More broadly, these findings motivate an integrative framework for understanding the neural basis of individual differences in decision-making competence (Talukdar et al. 2018).

Research in cognitive psychology has investigated several pathways to improve metacognitive skills including skill-based cognitive training and mindfulness meditation. A large empirical literature on the efficacy of cognitive training programs, involving the guided practice of specific cognitive tests to enhance executive functions and decision-making (Zwilling et al. 2019), indicates that training of executive functions can promote specific cognitive skills (e.g., inhibition, interference control, and working memory) but typically does not generalize to improvements beyond the trained tasks (Au et al. 2014; Simons et al. 2016; Soveri et al. 2017; Butler et al. 2018). Although still very much an active area of research, transfer of metacognitive training may be more effective (Jones et al. 2020; Schaeffner et al. 2021) than transfer of cognitive training, which demonstrates limited generalization (Sala and Gobet 2017, 2019).

Accumulating evidence indicates that the neural mechanisms underlying improvements in executive function from cognitive training are due to changes in functional connectivity, such as increased neural synchrony between frontal and parietal regions (Constantinidis and Klingberg 2016). Potential drivers of this increased functional connectivity include stronger synaptic connections (Gibson et al. 2014), increased myelination of the connecting axons (Yeung et al. 2014), or increased release rate of dopamine (Backman et al. 2011). The central role of executive functions in metacognitive skills (del Missier et al. 2012) motivates the application of interventions from cognitive psychology—which are designed to target the cognitive and neural mechanisms underlying executive functions—to

enhance metacognitive awareness. This represents a promising direction for future interventions and studies that aim to confer benefits that generalize beyond the training context.

An emerging area of research in psychology investigates the beneficial effects of mindfulness meditation on metacognition. Evidence indicates that mindfulness training cultivates moment-to-moment awareness of the self and environment (Wallace 2006) and to this extent, mindfulness training heightens metacognition (Austin 1998). This provides a pathway to explain robust experimental findings on the impact of mindfulness training on metacognition (Zeidan et al. 2010; Solem et al. 2015). Neuroscience evidence further demonstrates that mindfulness meditation induces changes in functional brain connectivity within the ventral attention network (Brefczynski-Lewis et al. 2007), dorsal anterior cingulate (Tang et al. 2009, 2010), medial frontal cortex (Hölzel et al. 2007), temporal parietal junction, and pons (Hölzel et al. 2011). These findings suggest that mindfulness meditation enhances the cognitive and neural mechanisms of executive function (which is an independent but highly overlapping construct with metacognitive awareness (Fernandez-Duque et al. 2000)) and motivates applications to metacognition.

A complementary literature in health psychology investigates the efficacy of moderate intensity physical activity and aerobic fitness training to enhance executive functions (for reviews, see Hillman et al. 2008; Voss et al. 2011; Guiney and Machado 2013). A recent meta-analysis demonstrates that physical activity and aerobic fitness enhances executive functions, observing an effect size gain of 0.34 across 36 studies (Northey et al. 2017). Neuroscience evidence further indicates that the observed improvements in executive functions are linked to the effects of physical activity and aerobic fitness on brain structure and function. A growing body of evidence indicates that aerobic fitness promotes efficient functional connectivity within brain networks for executive function, primarily within the fronto-parietal network (Colcombe et al. 2004; Voss et al. 2010a, 2011). For example, Voss et al. (2010b) demonstrated that a 1-year walking intervention was associated with increased functional connectivity within the fronto-parietal network of healthy older adults. Taken together, evidence from health psychology and neuroscience demonstrates that aerobic fitness improves executive functions, suggesting that physical fitness may have beneficial effects on associated skills for metacognitive awareness.

The reviewed findings support the efficacy of modern interventions from psychology to enhance metacognitive awareness and associated executive functions. Although unimodal approaches to intervention represent the most commonly applied method, an emerging body of evidence examines the efficacy of multi-modal interventions designed to leverage the beneficial effects of multiple intervention modalities. For example, recent evidence demonstrates that multi-modal cognitive and physical fitness training produces greater improvements in executive functions compared to unimodal training (Fabre et al. 2002; Oswald et al. 2006; Ward et al. 2017; Daugherty et al. 2018; Zwilling et al. 2019). A meta-analysis investigating the combined effects of cognitive and physical fitness training across 20 studies concluded that multi-modal training delivers synergistic effects that enhance performance more than physical fitness training or cognitive training alone (Lauenroth et al. 2016). Although the mechanisms underlying the beneficial effects of multi-modal training are still under investigation, animal models suggest that both cognitive and physical fitness training may promote neural plasticity and stimulate neurogenesis (Fabel 2009). These findings support the efficacy of multi-modal interventions—providing evidence that this approach can enhance performance on tests of executive function and further motivating their potential for the promotion of metacognitive awareness, collective intelligence, and subjective wellbeing.

4. Summary

In this short review article, we brought together findings from psychology, cognitive neuroscience, and the social science of intelligence to argue for a virtual cycle of global wellbeing that can be accelerated via interventions to enhance individual metacognition (due its central role in collective intelligence). Notably, there are methods from cognitive

training, mindfulness meditation, and kinesiology that have been demonstrated to enhance metacognitive awareness, which can be deployed as large-scale interventions. As noted, promoting global population-level and individual wellbeing via improved metacognition will be fundamentally intertwined with addressing vexing societal problems such as inequity.

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How Wisdom Emerges from Intellectual Development: A Developmental/Historical Theory for Raising Mandelas

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Abstract: This paper invokes cognitive developmental theory as a means for preparing citizens to deal with and resolve conflicts within or across nations. We take the centuries-old Greek–Turkish dispute as an example. We first outline a theory of intellectual development postulating that mental changes emerge in response to changing developmental priorities in successive life periods, namely, interaction control in infancy, attention control and representational awareness in preschool, inferential control and cognitive management in primary school, and advanced forms of reasoning and self-evaluation in adolescence. Based on this model, we outline a control theory of wisdom postulating that different aspects of wisdom emerge during development as different levels of control of relations with others: trust and care for others in infancy, taking the other's perspective, reflectivity, and empathy in preschool, rationality and understanding the rules underlying individual and group interactions in primary school, and understanding the general principles of societal operation explaining the differences in approach and interest between groups in adolescence and early adulthood. We also outline the educational implications of this theory for the education of citizens by capitalizing on intellectual strengths at successive developmental periods to comprehensively understand the world and to act prudently when dealing with interpersonal and social or national conflict. Finally, the paper discusses the political constraints and implications of this theory. This is the first attempt to derive wisdom from the development of cognitive and personality processes from infancy through early adulthood and to connect it to serious world problems.

Keywords: intelligence; cognitive development; wisdom; education; conflict resolution; problem-solving; decision making; history-wars

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The modern world is a world of nation states and the foundation history of the nation states is a history of warfare. There is almost not a single nation state that did not emerge from war. Wars create a background of nationalism and uneven development which protract conflict and tension between or within countries for a long time after they end. Conflicts and tensions compromise life and well-being. One such conflict is the conflict between Greeks and Turks. The Greek nation state emerged from an independence war against the Ottoman Empire (1821–1828); modern Turkey was founded as a modern nation state after a war with Greece (1919–1921). Cyprus is a battlefield where the Greek–Turkish conflict is endlessly protracted. The national desire of Greek Cypriots to unite with Greece and counter the national desire of Turkish Cypriots for division of Cyprus between Greek Cypriots and Turkish Cypriots turned Cyprus into a hotspot of ethnic conflict, where the end of history (Fukuyama 1992) is still far away.

The Republic of Cyprus emerged as an independent state from a war against British colonialism (1955–1959) and was established as a constitutional bi-communal state governed by its two dominant communities, Greeks, about 80% of the population, and Turks,

about 18%. Obviously, historical forces were too strong for the small young state to overcome. Even more so, the division between the two communities was institutionalized in the constitution: although political bodies, such as the government, the parliament, and public administration, were proportionally shared by the two communities, education was separate and under the jurisdiction of an independent body in each community. This was enough to perpetuate separatist and conflictual national narratives, undermining the very functioning of political institutions. The state collapsed soon after independence, in 1963, because of strong disputes about distribution of power between the two communities and lack of unifying pressures coming from the people. Since then, inter-communal tensions and conflict never ended and peaked in a coup and civil war within the Greek Cypriot community in 1974; as a result, a Turkish invasion followed, causing displacement of about one-third of the population and occupation of one-third of the island by Turkish forces since then. Negotiations about a political settlement of the dispute have continued under the auspices of the United Nations since 1963. In the words of a UN envoy, negotiations in Cyprus go well as long as they go on!

Our position here is that the consequences of this dispute for the life of people are disproportionately large. The issues at stake changed drastically over historical time, so that division and conflict cause more harm than profit for any other than those perpetuating their power by capitalizing on division, such as political parties and politicians across the divide. In fact, none of the causes that ignited the Greek revolution against the Ottomans or the wars in the late 19th and early 20th century between Greece and Turkey is currently active. However, the leadership and the peoples in Greece, Turkey, and Cyprus refrain from making decisions that would bring the conflict to an end. Legalistic disputes about distribution of power and jurisdiction in a common federal state draw on the centuries-old Greek–Turkish conflict which fuels current political disputes and conflicts of interests with historical arguments within and across the two nations. It is well known that perpetuating negative narratives about the other in groups with conflictual relations facilitates further conflict, preventing search for means that would facilitate overcoming the conflict (Psaltis et al. 2020). This background causes lack of trust and tolerance, ethnic and nationalist tension, and self-perpetuating hostility drawing on misdeeds against each other.

Some scholars proposed that the average level of intelligence in a population is related to the level of democracy, technological advancement, and prosperity and the ability to efficiently resolve tensions and disputes with other countries or between groups within a country (Rindermann 2018). The higher the level, the better it is for peace and well-being. Rindermann suggested that wars in the modern world abound in regions where secular intelligence is considerably lower than the standard average. However, it is questionable whether current theory of intelligence would suffice to help nations to overcome disputes. Rindermann's argument above may be cyclical: there may well be social and political factors other than individual intelligence causing national or social success, which subsequently result in provisions raising individual intelligence, such as generalized education. In fact, international history abounds with examples where advanced nations made fatally self-defeating decisions, including Germany, Rindermann's country.

We argue that no theory of intelligence or intellectual development suffices to generate solutions for serious social or political problems. To be useful for this sake, any theory would have to be much broader, accounting for individual and social development on several fronts, such as the following:

1. This theory would have to account for both (a) individual mental development and (b) the contribution of individual development to the functioning of the social groups and institutions at various levels, increasingly distancing from an individual's own life, such as family, city, nation, and humanity. This requires understanding how cognitive, social, moral, and personality development interact. Currently, no comprehensive theory exists that would do justice to these interactions. Piaget's theory might have been the closest approximation to it, delving into the common core of intellectual

(Piaget 1968), social (Piaget 1951), and moral development (Piaget 1932). However, Piaget's theory, gearing every aspect of understanding on the development of logical reasoning, is not accepted anymore. Current theories are too fragmented to satisfy the requirements above (see Demetriou and Spanoudis 2018).

2. This theory must have explicit provisions for education. Education needs developmentally informed guidance to (a) set clear goals, enabling smooth and functional integration of cognitive, social, emotional, and personality characteristics of individuals to serve social, political, and productive institutions and (b) efficiently implement them (Demetriou and Spanoudis 2018). Developing citizens must learn early in their life to consider conflicting points of view and preferences and integrate them in constructive syntheses, given the present situation but also the future. Finally, provisions are needed for the organization and functioning of social and political institutions, such as parliament and other decision-making bodies, to guide social and political goal setting and problem solving, enabling the handling of strong historical forces that compromise the present and future of people.

1. Historical and Epistemological Concerns: How Wisdom Emerges from Intellectual Development

The developmental model outlined here draws on two major sources: current theory and research on intellectual development and current theory and research on wisdom in dealing with important life problems and societal issues. We argue that intellectual development and the development of wisdom are more closely related than assumed in the literature. Our central position is that neither of these lines of research alone is sufficient for the attainment of the aims above. The theory of intellectual development focuses on cognitive processes in childhood and adolescence. The theory of wisdom focuses on a specific approach to problem-solving and decision-making in adulthood. Historically, the two fields operationalized constructs differently. However, thinking and problem-solving in actual life need not respect the boundaries of different research fields in psychological research.

The psychology of intelligence adopted Binet's (Binet and Simon [1908] 1948).) priorities for studying intelligence in the early 20th century. These focused on mental processes which are important for school learning, such as reasoning, language, and comprehension of concepts. The field was admirably successful in identifying individual differences in these processes and directing educational decision-making accordingly (Anastasi 2005). The psychology of cognitive development, under the influence of Piaget (1968), focused on the development of reasoning (Flavell 1985). Notably, Piaget's career as a researcher started in Binet's laboratory. Additionally, as an epistemologist interested in the nature and origins of knowledge, Piaget prioritized the study of logical reasoning and understanding philosophically defined categories of reason, such as number, space, and causality, rather than life-important decision-making. Piaget's ideas caused important progress in our understanding of cognitive development. However, both the individual differences and the developmental approach to cognition did ill-justice to problem-solving and decision-making of broad social or societal interest, the focus of this article.

The study of wisdom has a different history. In classical Greek philosophy, wisdom involves *nous* (mind), discerning reality, and *episteme*, knowing and reasoning on universal truths. Phronesis involves the ability to make correct decisions and reflect on experience for important life matters. Current psychological theory and research on wisdom includes both ancient constructs (Ferrari 2009). It is considered a complex state of mind and personality enabling adults to use personal life experiences and a broad knowledge basis to make prudent judgments about complex personal, interpersonal, and social problems, which are recognized as inclusive, balanced, moral, and beneficial for everyone involved (Ardelt et al. 2019; Baltes and Smith 1990; Staudinger 2008; Sternberg and Karami 2021).

Wisdom so conceived is intelligence at its best. The road to it is intellectual development, gradually constructing a scaffold of thought enabling one to discern and evaluate reality, know universal and historical truths and reason on them, make practically beneficial

decisions given the situation, and reflect on them to become better for the future. Wisdom has been an object of research on adult development but not of development in childhood, *underestimating the fact that wise adults have been children*. The study of cognitive development focused on changes in cognitive processes from infancy through early adulthood, but it did not examine how problems of everyday childhood or adolescence are resolved. The position of this paper is that all aspects of wisdom have precursors in early cognitive development. Thus, our central concern is to ensure that wisdom will gradually emerge from each phase of intellectual development, preparing citizens to deal intelligently and prudently with personal, national, and international issues involving conflict.

2. Empirical Concerns: How Wisdom and Intelligence Are Related

All theories assume that wisdom includes intelligence and much more. This is reflected in the moderate correlation, circa.3, between various processes addressed by intelligence research, such as processing speed, reasoning, and vocabulary, and processes addressed by wisdom research, such as integration of multiple points of view, ethical considerations, and self-transcendence (Glück 2020a, 2020b; Grossmann et al. 2020). In neo-Piagetian theory, wisdom was associated with attaining formal or postformal reasoning (Kallio 1995). Therefore, there is wide agreement that "wisdom is not a form of intelligence, nor is intelligence a form of wisdom" Glück (2020a, p. 17). Wisdom requires the following processes: (1) cognitive processes underlying intelligence, such as reasoning, reflection, and metacognition; (2) creativity to conceive of new solutions and interpretations, if old solutions do not suffice; (3) knowledge of the persons and situations requiring solutions, "the pragmatics of life"; (4) products (ideas and solutions) balancing interests of the parties involved, which are recognized by all to advance common good; (5) the motivation and affectivity to act accordingly (Sternberg and Karami 2021; Sternberg et al. 2019). Processes in points 1 and 2 become increasingly integrated and abstract with development, accounting for individual differences in cognitive ability. Points 3 and 4 draw on the processes in 1 and 2 to acquire knowledge and skill in different conceptual or activity domains. Mastering these domains requires drawing on the first two types of processes in the fashion required for mastering other complex domains, such as science. Processes in point 5 relate to motivation and dispositions to get involved in all other processes.

Thus, intelligence–wisdom relations appear as an investment cascade: fluid reasoning together with certain interests and personality dispositions allow the construction of a broad knowledge base underlying crystallized intelligence, which may be extended, by some people, into the "big questions" of human existence. Some of these people may capitalize on their own and others' life challenges and develop wisdom, if some intellectual possibilities are present and if they have certain personality qualities, such as openness, empathy, and self-reflectivity. According to Glück (2020a), wise people have high levels of intelligence, and they are open, reflective, empathic, and ethical; however, not all intelligent people are wise.

Some complex domains, such as science, are learned in systematic long studies. No such program exists for wisdom. Theories of wisdom assume that becoming wise requires long-term life planning, optimum life management, and life review, allowing to make meaning of past decisions and actions and optimize future ones (Baltes and Smith 1990; Staudinger 2008). Thus, learning by doing is assumed. The present article suggests that wisdom might develop more broadly if wisdom-building mechanisms are properly guided to become invested with the knowledge required together with handling the personality dispositions required to provide the emotional context and motivation for wise thinking and decisions. In other words, we suggest that education for wisdom must be part of a program aiming to support intellectual development.

The model of wisdom-based reasoning provides the operationalization of wisdom that is necessary for the development of a program for educating wisdom that draws on intellectual development. This model postulates that wise thinking draws on four aspects of cognition (Brienza et al. 2021; Grossmann 2017): (a) intellectual humility, emerging

from recognition of the limits of one's own knowledge; (b) recognition that there may be multiple points of view or perspectives or that a current issue of concern belongs to a broader context; (c) recognition that views or interests often change in social relations or in time; (d) systematic search for the integration of different opinions, which implies recognition of compromise as part of social decision-making. We show below that all four aspects of cognition required for wisdom-based reasoning are acquired in early and middle childhood as building blocks of cognitive development.

3. A Cognitive Developmental Theory for Intelligence and Wisdom

3.1. The Mental Architecture

The theory of intellectual development we employ makes four fundamental assumptions (Demetriou et al. 2018a; Demetriou and Spanoudis 2018).

First, the human mind involves mental processes that carry out different tasks for understanding and problem-solving, namely, control functions, enabling focusing on information and action critical at a given moment and updating as required; integration functions, enabling grasping relations, generalizing, and validly filling in missing information; and cognizance, enabling awareness of the objects of mental activity and mental processes.

Second, these processes are functionally intertwined, always operating together as a unit at various levels, from perception to abstract thinking; meaning-making emerges from their integrated functioning. This unit, named noetron, after nous, the Greek term for mind (Demetriou et al. 2021), operates as a "master-algorithm," coordinating current goals and relational integration with awareness of mental processes, their objects, and contents. Noetron is constantly updated in reference to the results of ongoing activity, mental or actual, coordinating feedforward expectations with feedback from the results of activity; matching feedforward with feedback information enables subjective experiences ascribing intrinsic values to mental states and activities, allowing choices among them according to their value suggested by successes and failures. Any organism lacking this form of a unifying mental agency would not be capable of capitalizing on a balanced combination of past knowledge and experience for the sake of future-oriented understanding or action. Ideally, this combination optimizes choices by selecting the best fitting experience or concept to vary, based on how the future is conceived. This is a fundamental condition for the development of wisdom, which is an advanced aspect of comprehensive intelligent judgment.

Third, noetron expands with development, generating increasingly inclusive repertoires of action or thought choices. In cognitive science terms, this expansion gradually generates a Language of Thought including tokens of experience and action (representations), rules for their possible legitimate relations (reasoning) (Fodor 1975), and exemplars from experience providing ready-made frames for rule implementation. In other words, noetron is embedded into an expanding system integrating perceptual experiences into representations by various forms of rules underlying forms of reasoning, such as inductive, analogical, and deductive reasoning, and problem-solving scripts. Increasing flexibility in choosing and using different forms of reasoning and scripts implies increasingly efficient levels of control, for instance, going from action control in infancy to representational control in preschool to inferential control in primary school to truth control in adolescence.

Fourth, with age, the profile of mental ability varies depending on the developmental needs for exercising control at successive developmental phases. Developmental priorities change with the functional state of noetron. When a process is highly demanded for efficient noetron functioning, mastering this process becomes a dominant developmental priority. Changes in mastering this process become highly helpful for learning and highly predictive of learning outcomes in various domains, including school learning (Demetriou et al. 2019b, 2020a, 2020b, 2020c). After a critical integration point in satisfying functional demands, the two may vary independently, because the formation of mental ability shifts to other priorities, showing dependence on other processes (Demetriou et al. 2017; Demetriou and

Spanoudis 2018). Developmental priorities and their relations with cognitive processes and wisdom are discussed below. Table 1 summarizes developmental priorities for cognitive and wisdom development and their educational implications.

Table 1. Dominant cognitive, wisdom, and educational priorities as a function of age.

Age	Cognitive Processes	Wisdom Processes	Education
Infancy (0–2 years)	Episodic representations; interaction control; attachment, reactivity, and emotionality precursors of personality.	Development of trust for others; feelings of mastery of interactions with persons and objects.	Controlled engagement in interactions with other persons and objects; systematic variation of action outcomes and management of ensuing emotionality.
Preschool (2–6 years)	Realistic representations; attention control and representational awareness; mastering symbol systems and imaginary worlds.	Recognition of uncertainly and limits of one's own knowledge. Recognition of others' perspectives. Emergent personality dispositions.	Guidance to reflect on one's own activities and perspective; listen to the others' stories; know the others' heroes and well-being. Explore the others' worlds.
Primary school (6–12 years)	Representation of rules; inference; inferential awareness; management of the inferential process. Personality characteristics tend to become established.	Specify the rules underlying different belief systems; search for integration and compromise; stay open and control emotionality.	Associate lines of argument with relevant belief systems; practice reflection from the other's point of view. Elaborate on the differences between each other's heroes and historical figures.
Secondary school (12–18 years)	Abstract representations; truth and validity control; accurate self-evaluation and self-concepts; personality dispositions are well established.	Transcend one's own subjectivity; recognize relativity of positions and preferences; recognize differences between principles; specify the limits of different principles.	Examine cognitive, emotional, and societal implications for different options; explore differences between belief systems, e.g., national history, religion, social narratives, etc.; enhance interests and satisfaction of all.

3.2. Developing Mind: From Cognition to Wisdom

Precursors of wisdom in infancy. Episodic representations dominate in infancy. These are mental states preserving the spatial and time properties of actions and experiences. Thus, interaction control, allowing efficiency of actions on objects, is the developmental priority of infancy (Demetriou and Spanoudis 2018). Cognitively, mastering interaction control provides the background for understanding that one's own actions may have implications for objects and persons and that taking control needs effort. However, strictly speaking, infants cannot be wise because they lack the representational resolution, integrative power, awareness, knowledge, and emotional stability required for wisdom. Mastering interaction control, the developmental priority of this cycle, sets the background for later attainment of wisdom. This background is set when interacting with objects and persons, exploring

differences across them, engaging actively with them but staying calm when results violate expectations, seeking help to improve interactions, and enabling the infant to realize that some solutions are better than others and that attaining them requires trying out alternative solutions.

Individual differences in emotionality and affectivity appear early in infancy and these may interfere in mastering interaction control (Soto et al. 2011; Roberts et al. 2006). Differences between infants in reactivity to persons and objects suggest that some infants are more likely than others to enter the road to wisdom. Infants high in activity, attraction to novelty, and inclination to affiliate, but low in intense emotional reactions predisposing for self-control are more likely to enter this road. Infants low in these attributes and high in emotionality need special care to take control of their interactions in a context of emotional security. Emotionally, mastering interaction control lays the ground for trust and security in dealing with oneself and others. Failing to protect infants from these weaknesses may channel them away from coherent, balanced, and beneficial interactions with others later in life.

Attaining intellectual humility, decentering, and recognition of uncertainty in early childhood. Realistic mental representations emerge from episodic representation at 2–3 years and are associated with symbols, such as words and mental images. These dominate in preschool, from 2 to 7 years. Hence, representational awareness and attention control are the major developmental priorities in this period. Mastering attention control enables the attainment of more complex cognitive tasks, such as organizing action according to represented goals, following ongoing verbal interactions, and exploring the behavior and interactions between other persons and objects (Demetriou et al. 2018a; Diamond 2013; Zelazo 2015). Mastering symbol systems, such as language, and subjecting action under the control of representation, renders awareness of representations and control of attention important. Awareness of representations enables individuals to become social partners and negotiate each other's views or intentions; it also provides a representational insight that views of reality are often mirrored in each person's representations. Preschool children's strong interest in the imaginary worlds of fairy tales and movies reflects humans' emergent realization that the world may be represented by alternative, often surprising, ways (Hinchcliffe 2006) and that using them helps explore their possible differences and functionalities (Dubourg and Baumard 2021). Education of tolerance and empathy may capitalize on the preschooler's discovery of imaginary worlds.

Notably, three of the four aspects of wisdom-based reasoning emerge in this period. The precursor of intellectual humility is children's awareness of their ignorance. Children talk explicitly about their own and others' knowledge and they admit their own ignorance (Harris et al. 2017). In addition, by the age of 4–5 years, children revise incorrect interpretations in the light of new information. By the age of 7–8 years, children are aware that visual or oral input can be ambiguous, and they differentiate the conditions of epistemic uncertainty from physical uncertainty (Robinson et al. 2006). This understanding predates recognition of uncertainty and change. Grasp of Theory of Mind (Wellman 2014) at 3–5 years strongly suggests that preschoolers understand that mental states and beliefs may differ between individuals, depending on the sources of information they have access to. These achievements are precursors of the recognition of others' perspectives and relevance to context (Hughes and Leekham 2004). They also predate the reflective stance about oneself and others, a pivotal component of wisdom.

Children high in awareness of others' mental and emotional states are more likely than children who are low in these processes to engage in activities leading to wisdom. These children may understand that activities and objects may be shared and that goals may be better attained by persons working together than one person working alone. If sociable, helpful, and generous to others, organized, systematic, planful, and creative, children may realize that they may have a role in leading shared activities and gaining satisfaction from success and praise. However, the reasoning needed to grasp the underlying causal relations between events and realities or between motives and their effects is still weak

in this cycle. Moreover, control of social interaction and openness to experience are not yet well refined and consolidated (Demetriou et al. 2018a, 2018b; Roberts et al. 2006). Together, these weaknesses hinder the recognition of problems of importance to a group and designing broadly beneficial problem-solving activities. Thus, synthesizing beyond one's own experience and perspective is limited.

For the present concerns, it would be useful if children in this cycle are guided to reflect on how their activities may be benevolent or may cause pain or distress in others (Weststrate et al. 2018). The keen representational interests of this cycle may be used to familiarize children with the experiences of children belonging to other groups and develop empathy for their agemates belonging to the other group. This requires ad hoc educational programs allowing children to listen to the stories *of the others from the others*, to remember the stories of others, and to hold group-specific narratives against each other. The aim is to build a conception of the world where self-centered attitudes and ethnocentric heroism are relativized vis-à-vis an overall human narrative where human life and general well-being dominate as standards for individual action (Kizilyurek 2019).

Search for integration and compromise in primary school. With representational awareness and attention control established by 5–6 years, priorities change in primary school, from 7 to 11 years. The relations between representations need to be worked out and accurately represented. Hence, cognitive priorities are redirected from knowing the represented world and coupling representations with the environment to the relations between representations and concepts themselves. Holding representations active for as long as required to process relations and connect them by inference are the major priorities of this period. Inductive inference is the major tool for grasping the relations between objects and concepts because it enables transfer of meaning from experience to novel situations. Therefore, processes for handling memory and inductive inference are the major contributors to the formation of general cognitive ability in this period. Explicit deductive reasoning emerges at the end of this period, from 8–11 years, reflecting the integration of inferential rules into a system where one representation may be systematically viewed from the point of view of others. It is notable that from 7–9 years, children recognize that two viewers or listeners might make different interpretations, depending on what information they have access to and the inference used to connect them (Kazi et al. 2019; Spanoudis et al. 2015).

Therefore, the fourth requirement for wisdom-based reasoning, the search for integration and compromise, emerges in this period of life. In rule-based thought, children have the mental capacity to employ reasoning to inter-relate activities and emotions with the requests or needs of others, such as parents, siblings, and school mates, when they diverge from intentions and wishes. This enables children to formulate concepts organizing one's own experiences and action plans, understand the role of rules and prescriptions in one's life, and use them to generate or negotiate solutions to problems. Rule-based thinkers may be aware of the underlying connections between concepts, events, and experiences, or actions, thoughts, and motives. They may also use previous knowledge or experience to anticipate consequences of actions or events. They can also be aware of different perspectives on the same event because they understand that information or knowledge causes differences in perceptions and attitudes, even if reasoning is the same. Therefore, rule-based thinkers may analyze problems rationally and can take a reflective stance toward others and problems, which is conducive to tolerance of alternative views and their possible synthesis into solutions going beyond one's own preferences.

However, rule-based thought often fails to grasp higher-order relations highlighting links between seemingly unrelated rules or systems; in addition, rule-based thought lacks truth control tools protecting from fallacious reasoning. This often causes personal biases and perspectives to dominate, especially if promoted by authority, in individuals who are not socially oriented, emotionally stable, or open to novelty. For instance, lack of openness may hinder individuals from seeing problems from the perspective of others. These individuals may not avail themselves to opportunities conducive to wisdom. In short, many adults do not reach wisdom if they stay in rule-based thought.

To deal with the weaknesses of rule-based thought, children in this cycle must be induced to explicitly grasp the rules under which conflicting groups operate. They must reflect on how conflicting rules may cause conflicting actions, which may in turn cause pain and compromise the interests and well-being of all persons involved. They must also be induced to redefine each other's rules so that commonly accepted and beneficial ones may be conceived and implemented. There is evidence that practicing distanced self-reflection in the third person about conflict situations increases wise judgments by widening one's own often narrow self-focus (Grossmann et al. 2020). In addition, teaching by example and historical role models may be the method of choice to enable rule-based thinkers to see how important figures approached complex problems and experience, from their point of view, the benefits obtained for themselves (becoming important figures in society) and others (improvement of their condition) (see Grossmann 2017).

Building wisdom-based knowledge in adolescence. Intellectual changes are consolidated in adolescence when controlled reasoning is fully established. Overarching principles integrating rules into systems according to truth and validity dominate in adolescence. Principles enable thinkers to grasp when it is and when it is not possible to use an inferential rule to infer a state of reality based on this rule. Thus, a critical approach to reality is possible. These processes strengthen until middle age. In addition, cognitive self-evaluation and self-representation become powerful factors in the formation of cognitive ability among university-educated persons in middle age (Demetriou and Bakracevic 2009; Demetriou et al. 2017). In adulthood, persons must take control of their life, regardless of how far they have gone on each of the cognitive and personality development dimensions discussed above. Entering the worlds of work, family, and citizenship without the protective shields provided by parents and schools imposes strong cognitive, personality, and social requirements.

Therefore, principle-based thought is, by definition, an important tool for transcending one's own subjectivity to view problems from the point of view of other persons or alternative contexts, a condition for wisdom (Ardelt et al. 2017, 2019; Demetriou n.d.; Kallio 1995). Sound deductive reasoning is a truth control system enabling persons to evaluate solutions and perspectives according to their truth, value, and scope in concern with the persons and stakes involved. The epistemic stance enables persons to realize that even the best solutions may be relative and subject to revision. Thus, at the individual level, these types of thought may guide the development of long-term life plans, such as choosing a course of studies or a profession, balancing value judgments for one's own weaknesses and strengths vis-à-vis a preferred lifestyle or social role. At the social level, they may enable individuals to grasp assumptions and prescriptions of multiple contexts in which they live and enable problem-solving, generating solutions, decisions, and courses of action that are optimal for the individual and other persons or institutions affected.

Scholars argue that higher levels of mental functioning, such as principle-based thought, openness, and higher levels of ego development, are complementary aspects of the same construct: the mature mind (Costa and McCrae 1993; McCrae and Costa 1997) which creatively integrates cognitive, personality, and emotional trends and proclivities in dealing with problems (Demetriou et al. 2018c). It is notable that wisdom in later life is associated with openness to novelty, mindedness, and well-being coming from having purpose in life, satisfaction, positive relations with others, environmental mastery, and a general concern for the well-being of others (Wink and Staudinger 2016). In this cycle, adolescents must be induced to consider the multiplicity of factors that may cause a conflict, such as historical, religious, political, and economic reasons and grasp their underlying principles. They must also be induced to consider historical events and decisions of political or historical figures from the point of view of all of the actors involved. This would enable them to understand that wise decisions are often those which may not appear right at the time they are taken. They must also be induced to understand that the modern narratives about these events may serve purposes other than the interests and well-being of the individuals or institutions involved.

4. A Developmental Model for Wise Conflict Management in Schools

In conclusion, we have suggested that wisdom is an emergent system of control integrating cognitive, emotional, and personality abilities and attributes for the sake of efficient, constructive, and self-enhancing activities and relations with others. This is a long process starting from infancy, building on attaining control of processes dominating in successive periods of life. The central idea is that childhood is important for integrating wise judgment into spontaneous cognitive functioning because satisfying the developmental priorities of each cycle causes the necessary build-up of the cognitive and personality characteristics required for wise judgment. Mastering interactions with persons and objects (infancy) provides the background for knowing that one's actions have implications for objects and other persons. Mastering executive control and becoming aware of mental worlds (early childhood) are necessary for judgments acceptable by many. Mastering inference and using it to organize understanding and action (middle and late childhood) is necessary for understanding that views and decisions build up mentally and are built on rule systems that may differ between persons or groups. Mastering principles, imagining possible worlds, and understanding that inference and interpretation may not always be true or valid (adolescence) is necessary for adopting the critical stance, enabling to analyze and explore truths and search systematically for truth. Mastering the art of balanced and constructive choices embedding judgments and decisions in societal, cultural, and historical perspectives requires knowledge and experience drawn from autonomous life (early adulthood). All of these must be acquired in a positive context enabling persons to take responsibility for their life, develop trust for others, and become motivated to be constructive for themselves and others.

The theory above may guide enhancement of tolerance for social and political differences and capitalizing on them for efficient and productive functioning in a world of differences and diversities in such a way that it may enhance learning in more classic school domains. Specifically, there is research showing that school performance at successive educational levels is best predicted by the processes associated with the developmental priorities of each developmental cycle: command of attention control processes and representational awareness at preschool, management of working memory and inductive reasoning in primary school, and mastery of deductive reasoning, language, and accurate self-evaluation at secondary school (Demetriou et al. 2019a, 2019b, 2020a, 2020b, 2021). Importantly, training of mental processes transfers to general cognitive ability only if aligned with developmental priorities: training on attention control and theory of mind in preschool (Rueda et al. 2012), training on working memory in primary school (Holmes and Gathercole 2014), and training on relational integration (Klauer and Phye 2008; Papageorgiou et al. 2016) and deductive reasoning schemes in secondary school (Christoforides et al. 2016).

5. Ending History Wars: Overcoming a Side-Effect of Democracy

National educational goals and priorities are shaped by the orientations and priorities of a society and the institutions implementing them (Demetriou 2013; Nisbett 2003). In modern states, educational goals and priorities exist at several levels, often in conflict with each other. Education is addressed to everyone, aiming to enable the understanding and use of complex knowledge and technology in societies where differences must be accepted and honored. However benign these aims are, they are often understood differently, and they are not unconditionally accepted by different groups and stakeholders. Parties and organizations compete for priorities and orientations of society, including education, because it prepares citizens for the future, thereby affecting their own existence and role. Modern states are governed by several authorities with time-limited overlapping mandates and mutually balanced powers. Therefore, shaping the aims of education and educational practices is complicated and tricky business.

It is assumed that the level and quality of education depends on the quality of democracy and vice versa. It is also assumed that the level and quality of education and democracy in a country causes improvement in the relations of this country with other countries, fa-

cilitating intelligent and wise analysis and resolution of disputes. Inversely, it is assumed that wars stem more frequently from authoritarian regimes than democracies. However, unfortunately, democracy may have its share in starting a war. In the national rivalry between Greece and Turkey, strangely enough, things proved more peaceful under authoritarian regimes or conservatist governments (Metaxas dictatorship 1936–1941, post-war Greek authoritarian governments 1945–1963 and 1967–1973) than under democratic rule and populist governments (George Papandreou's government 1963–1967 and Andreas Papandreou's governments in the eighties). This may be ascribed to the major influence that well-preserved nationalist ideas have on the public sphere and public opinion. These are preserved in the national narrative by education. They are often part of identity-building policies that shape the orientations of education in both Greece (Liakos 2008, 2011) and Turkey and Cyprus (Kizilyurek and Gautier-Kizilyurek 2004). Individual identities and related attitudes and feelings are then exploited by politicians to increase their political appeal and access to power. In a sense, fossilized national narratives function as political traps channeling nations to wrong directions, because people's rule and democracy are not always compatible with the relativization of national differences and the culture of rights of minorities and different groups within a nation or multinational entities, such as the European Union or multinational countries. National rivalry comes not from the elites, but from the peoples themselves.

History wars often reflect this situation and become a tool of democratic functioning, protracting real wars or social polarization within societies. Obviously, this interpretation does not imply that we favor authoritarian over democratic governance. On the contrary, it highlights the hurdles of democracy with the aim to remove them from political practices for the sake of its further development. It is the task of education to raise critical and wise citizens from infancy through adulthood. Hopefully, this would enable nations to properly understand and weigh social and international problems when dealing with conflict and rivalries. Even this benign aim may be disputed because it might be interpreted by some to endanger the continuation of a nation as a distinct entity in time and space. Thus, provisions are needed to ensure that wisdom-based education and upbringing are accepted and implemented by all nations involved. Perhaps, the European Union is the most interesting historical and political experiment designed to achieve these aims.

However, even this is disputed, especially in nations where national, social, and political orientations are not settled. In these nations, the ideal for a European citizen is often interpreted with caution, because no commonly accepted answer exists on how much a European identity may be integrated with national identity. In Greece, there is still insecurity toward Europe because many believe that it endangers national religion, values, and traditions (Stavridi-Patrikiou 2007). In Cyprus, there is an ongoing discussion that the establishment and success of the state of Cyprus will eventually compromise Greek identity, among the Greek Cypriots, or Turkish identity, among the Turkish Cypriots, in favor of a Cypriot identity. Political parties or other institutions, such as the Church, object to the development of new curricula in several subjects, especially history, language, and religion, because they are concerned that this is ill-intentioned, aiming to increase distance between Cyprus and Greece (or Turkey, depending upon the community). A few years ago, a new curriculum, developed under the leadership of the first author as the then Minister of Education and Culture, with the aim to develop a culture of historical reconciliation and mutual tolerance between the Greek and the Turkish Cypriot ignited fierce history wars among the Greek Cypriots and was strongly opposed by many, with the Church in the lead. The Archbishop of Cyprus went as far as to state in public that he "will invite people to burn the new history books" because they supposedly endanger national history, as he himself understands it. In fact, a new history war started again while this revision, about the teaching of the role of Ataturk during the Greek–Turkish war in the early 20th century, was in progress. Many stars would have to align before the implementation of psychological models, such as the present one, would change society. Without this alignment, these models may appear as an interesting academic exercise, at best.

Mandela was a wise man who led his country to end apartheid, a long and very painful conflict between the white and black populations of South Africa. Four Mandelas may be needed to resolve the Greek–Turkish dispute: one in Athens, one in Ankara, and two in Nicosia (a Greek Cypriot and a Turkish Cypriot). We do not have them yet. Perhaps, we will not have them for as long as populist nationalist elites across the divide instrumentalize historical and political disputes about nation and national identity. After all, Mandela emerged from South Africa's prisons, not its schools! However, it may be time for countries that shaped history for centuries, such as Greece and Turkey, to protect their citizens and future generations from war, letting their Mandelas to emerge from their schools rather than from battlefields or prisons.

These Mandelas would have to understand the history of both nations in the long term; they must understand the reasons which caused their conflict in the past and the reasons which caused changes in their relations over the centuries. They must also understand that relations between nations change with changes in the wider historical and cultural context. For instance, neither Greece nor Turkey or Cyprus operate in the context of the Byzantine or the Ottoman empire; they rather operate in a completely different context, including the European Union. The distribution of power and influence is not primarily dependent on military power but on other forms of soft power, such as science and cultural productions. In this regard, cooperation is a win-win multiplicative factor of power and influence; military competition is a loss-loss factor weakening all nations involved in many different respects. If education would raise a majority of Mandelas in both nations (in all nations for that matter), then naturally Mandelas would emerge in the leadership of both nations, leading them to a new chapter in their history.

This paper outlined a theory of individual-social development that may help raise them and call them to service. Raising Mantelas in this fashion will enable nations to overcome historical conflicts in which they are trapped. Times scales in the resolution of these problems are much larger than individual lives. Thus, raising many Mandelas in education may be the optimal management of the future by societies trapped in their past.

6. Conclusions

In short, a theory of intellectual development that may lead to a deeper and more comprehensive understanding of social and political problems and to collective wisdom was outlined. To our knowledge, this is the first theory attempting to derive wisdom from the development of cognitive and personality processes from infancy through early adulthood and connect it to serious world problems. This theory aims to (i) advance a deeper understanding of social and political problems since early childhood, (ii) advance individual wisdom for the sake of social well-being and long-term human interests, and (iii) guide education to capitalize on developmental priorities to develop knowledge and mental skills conducive to a wise decision-making ability when dealing with conflicts and disputes. Obviously, this model needs to be tested empirically. Ideally, longitudinal evidence would show that individuals performing high in childhood on tasks addressed to recognition of one's own ignorance, understanding others' perspectives, and integrating rules in overarching systems serving the interests of different individuals are more likely to demonstrate wisdom in real-world problems in adulthood. This type of research is time and resource demanding. Alternatively, training of these processes would have to generalize to the four aspects of wise reasoning and cause changes in inter-group attitudes in the fashion found by Brienza et al. (2021).

It was also argued that long-held national narratives and convictions may be incompatible with attaining these aims. The mechanisms for choosing individual leaders in modern democracies and their political functioning when chosen may be incompatible with international and supra-social goal setting and dealing with conflicts. Leaders are mostly elected by nations or different political and social groups to maintain and enhance political, social, and economic interests of their constituencies. Therefore, the success of the present model would be facilitated if political institutions are founded that would ensure

integrative, wise, and future-oriented policies and practices rather than policies trapped into the past and motivated to sustain historical divisions and tensions. Probably, countries need a Wisdom Authority to watch and guide analysis and decision-making of problems. Only Mandelas would have to stuff a country's Wisdom Authority.

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Essay

Transformational vs. Transactional Deployment of Intelligence

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Abstract: The late James Flynn, to whom this Special Issue is dedicated, suggested that what will matter most to the future of the world is not levels of intelligence but rather how intelligence is deployed. In this article, I argue that we can distinguish between transactional and transformational deployments of intelligence. Loosely following Flynn, I suggest that we need to pay much more attention to the latter rather than the former.

Keywords: intelligence; IQ; giftedness; transactional giftedness; transformational giftedness

1. Introduction

The late James Flynn, to whom this symposium is dedicated, is best known for discovering the so-called "Flynn effect," by which IQs rose worldwide roughly two standard deviations during the 20th century (Flynn 1984, 1987). However, Flynn had many insights, at least one of which is arguably just as important as his insight regarding the Flynn effect. This insight was that the progress of civilization in the 21st century would depend more on how intelligence is deployed than on how much of it any of us has (Flynn 2007, 2013). In its measurement of IQ as well as scores on a variety of standardized tests used for various admissions, financial aid, employment, and other purposes, society focuses on the "amount" of intelligence. However, the future of the world depends, as Flynn recognized, not on those with the highest intelligence but rather on those who use their intelligence to the best ends.

2. Transactional versus Transformational Giftedness

In some of my recent work, I have distinguished between transactional and transformational giftedness (Sternberg 2020a, 2020b, n.d.) These concepts are borrowed from the literature on kinds of leadership, in which leadership theorists have distinguished between transactional and transformational leaders (e.g., Bass 1998; Bass and Avolio 1994).

I have defined *transformational giftedness* as giftedness that is transformative—transformationally gifted individuals seek positively to change the world in some way at some level. They try to make the world a better place. Thus, transformational giftedness focuses on positive and meaningful change, following a model proposed in previous work, ACCEL—active and concerned citizenship and ethical leadership (Sternberg 2017, 2019a). This model was proposed as a way to make education at all levels more responsive to the world's needs.

Transactional giftedness is giftedness that is based on exchange of resources. It is tit-for-tat in nature, with an individual seeking personal benefit in exchange for some amount of effort devoted toward a societally sanctioned endeavor. Society makes its contribution by identifying particular young people as gifted or talented or at least as having high potential. Those young people then are given augmented resources, such as admission to higher tracks in public schools, or to special prestigious public schools, private schools, colleges, universities, and later, first jobs. In return, those identified as "gifted" or "talented" are expected to graduate on time, earn good grades, earn honors, succeed in the prestigious jobs they enter, earn good incomes, and the like. Transactionally gifted people thus are successful based on their personal accomplishments, not on what they have achieved for

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others Those transactionally gifted individuals who do not render these accomplishments are viewed as having failed to live up to their potential. They are the unfortunate detritus of an otherwise successful system of funneling people into appropriate channels for their abilities and talents. To the extent that they fulfill their transactional expectation, they help create a correlation between predictions of their success and their attained success.

Transactionally and transformationally gifted individuals have different motivational systems. Transformationally gifted individuals deploy their intelligence and other germane abilities into making a positive, meaningful, and transformative difference; transactionally gifted individuals deploy their intelligence and other abilities to achieve gain for themselves and those who are important to them. They focus on societal and professional systems of reward and punishment. The transactionally gifted individual may make a positive difference; but they do so because of the personal rewards that may accrue because of their thoughts and actions. The transformationally gifted are not averse to such rewards, but what drives them is the positive, meaningful, and transformative difference they make.

Transactional and transformational giftedness are not mutually exclusive categories within a person: Gifted individuals are not one or the other. Rather, these kinds of giftedness are partly situational. Transformationally gifted individuals are transactional when they need to be but are transformational when the opportunity arises or when they can create the opportunity. Transactionally gifted individuals rarely or never perceive or create the opportunities in which they can be transformational.

Although I have focused on giftedness, the concepts of transactional and transformational giftedness apply at any level of intellectual ability. Basically, a transaction is an exchange between people. *Intelligence, as we currently measure it, is transactional*. An individual answers questions on a test. That individual is given credit each time they produce an answer that the test-creator deems to be correct. If the individual is credited with enough correct answers, the individual is described as highly intelligent. If the individual does not answer so many questions correctly, the individual is deemed to be not so intelligent. Either way, the currency of the transaction is correct answers from the examinee to questions posed by the examiner, and the rewards that ensue from the correct answers.

James Flynn's insight was that what matters most, at least, going forward, is not the amount of the transaction, but what is done with it—how the resources are deployed. Our societies have created educational and occupational systems based on an illusion—that just having more of something will somehow generate better outcomes. However, resources do not always predict societally useful deployment of those resources. For example, there are many wealthy people, with lots of money, who use the money only for their own benefit, and who actually leverage that money to seek benefits for themselves at the expense of the less fortunate. Similarly, the world is full of people with elevated IQs who leverage their IQs for their own benefit but who make little effort to do good for the world. They simply do not prioritize whether they do or do not. Or they may make things in the world worse.

3. What Does Transactional Intelligence Buy Society?

Ever since the early 20th century, there have been countless psychologists who have hoped that somehow having an IQ or other score based on a standardized test of academic abilities somehow would translate into meaningful contributions to society. This kind of wishful thinking started with Terman (1916, 1925) and continues to the present day (Sternberg et al. n.d.), with the promoters of this legacy themselves beneficiaries of a system that funneled them through, in part because of their high scores on standardized tests. The legacy with which we have been left is not so different from that which, at various points in history, gave enormous preferences and benefits to people who were white, male, high-caste, or whatever, and then pointed out that they tended to be more successful; the system failed to take into account that the preferred groups were given the additional resources to succeed that others who did not have the preferred attributes were not given. In fact, the correlation between status variables and later success was not "discovered," but rather, in large part, "created" by societal systems of reward and punishment that

separated those with more of the desired attributes from those with less of them. It is perhaps too easy to sing the praises of a system that has allowed one to attain the status to sing those praises.

IQ and level of education are highly correlated (Ceci 1996). In particular, there appears to be an increase of about 1.9 points of IQ per year of education (Tommasi et al. 2015). However, Senior (2020) pointed out just how little meaning IQ, and the superior education it can bring, have for one society, that of the U.S. More than one third of current members of the U.S. House of Representatives have a law degree; more than half of Senators do. Twenty-one House members and four House members have MD degrees, and the exact same numbers have some other kind of doctorate in each chamber. In all, 95% of House members and 100% of Senators have at least a bachelor's degree. How have these highly educated politicians performed?

The 116th Congress (current as of when I am writing) enacted 252 laws. That is by a substantial margin the fewest laws of any Congress since 1973 (when my source—https://www.govtrack.us/congress/bills/statistics–first started compiling records). This is not a political statement—it is simply a fact representing a record weak level of accomplishment for the most educated Congress ever (Burgat and Hunt 2018).

As Sandel (2020) has pointed out, the problem is that advances in education and, I would add, the corresponding increases in IQ, do not seem to buy good governance. What instead this alleged meritocracy buys us is a largely hereditary aristocracy of the highly educated, much as we have had with people who are of a particular race, sex, caste, or religion, many of whom have argued for the merit of the particular group to which they happen to belong. The problem is not limited to politicians. Some of the privileged become politicians, others become whatever, including psychologists studying whatever, including intelligence.

A point similar to Senior's was made by Halberstram (1993) in pointing out how some of the best minds in the U.S. got us into the quagmire of the Vietnam War. Higher education, IQ, school achievement—they had all of that and more, but they did not deploy their intelligence in an effective and transformational way. Rather, they acted foolishly (Sternberg 2005), because intelligence provides no protection whatsoever against foolishness.

Carnes and Lupu (2015), in a study of 228 countries between 1875 and 2004, extended these findings. They found that college education of leaders did not mean reductions in inequality, increased G.D.P., fewer strikes, reduced unemployment, or fewer military conflicts. In other words, education seems to have bought leaders of governance little or nothing.

Perhaps those aspects of intelligence as measured by IQ fare better in predicting success in domains other than leadership. However, rather than asking this question, we might ask the question James Flynn posed, which is essentially one of whether we should not pay more attention to how intelligence is deployed rather than to how much intelligence, measured by IQ or anything else, people have.

4. Operationalizing Transformational Giftedness

My colleagues Aakash Chowkase, Ophélie Desmet, Sareh Karami, Jenna Landy, Jennifer Long, Jialin Lu, and I are currently engaged in research using a first-pass 2020 version of a transformational-giftedness scale (Sternberg Transformational Giftedness Scale) (see Table 1). This measure is presented not as a validated scale but rather as an indication of an operationalized direction we believe the study of the transformational deployment of intelligence can take. We are construct-validating the scale against measures we expect to converge (e.g., adaptive intelligence—Sternberg 2019b, 2021) and ones we expect to diverge (e.g., conventional tests of intelligence).

Table 1. STGS: Preliminary Version.

Part I	1. Write a paragraph about what your future dream life in 25 years would look like, with the constraint that there is a chance of achieving it. 2. What are you passionate about? How would you expect that passion to affect your future life? 3. Design an App. What is its purpose and how does it accomplish it?
Part II	1. What would you most like to accomplish in your life? How will you get from where you are to where you want to be to accomplish that thing? 2. What are two other things you would like to accomplish in your life? 3. When you are older, how will you decide if you are satisfied with what you have done in your life? 4. What do you see as the biggest obstacle to accomplishing your principal goal in life and how will you overcome it?
Part III	1. Pick a major world problem. What are things you personally could do to help solve the problem? How could you do them? 2. What are things the country in which you live could do to help solve the problem you chose? How could the country do them? 3. Have you done anything in your life that you believe helps to make the world a better place? If so, what?
Part IV	What is the one thing you have done in your life of which you are most proud? Why are you proud of it?
Part V	If you were to change one thing in the world, what would it be?
Part VI	1. Martin Luther King and Mahatma Gandhi both defied the laws of their times and went to prison for their beliefs. Did they do the right thing in defying the law? Why or why not? 2. Suppose you had a belief about how things in the world need to change. But other people close to you told you they disagreed with you. What would you do? 3. Do you think there might be a time in your life when it will be better to be right than to be well liked? If so, what might an example be?
Part VII	1. If a lot of people believe something, do you generally conclude that it is most likely true? Why or why not? 2. Have you had any beliefs that you used to accept but that you no longer accept? If so, what changed your mind, and why? 3. Can you think of a belief most people have that you do not accept? If so, what is it and why do you not accept it?

Scoring: Scoring is by the consensual assessment technique. Judges are asked to rate the extent to which each response reflects, on a 1–5 scale, a transformational rather than merely transactional mind-set.

Our goal is not to measure intelligence. It is rather to measure how young people hope to deploy their intelligence in the future. We are only now starting to collect data, but I publish the scale here in its preliminary form in the hope others might seek to explore use of the scale or its analogs. Our goal is to show that transformational deployment of intelligence cannot only be conceptualized but also can be operationalized. Ultimately, we would like to link the scale to transformational accomplishments in society. Again, I emphasize that this research is only just beginning.

5. Conclusions

Ever since Terman's time, many (but certainly not all) psychologists, especially in the gifted field, have been "apologists" for testing of IQ and related constructs as largely sufficient in themselves for identifying the intellectually gifted. This enterprise has helped to create an enormous self-fulfilling prophecy, whereby those who are identified as being gifted or talented or precocious, or whatever, are given the resources to succeed. Those who are not identified are not given comparable resources. A funnel is created that benefits those who already are genetically and environmentally benefited, for example, by well-educated parents. The environmental funnel augments the effects of what may be small genetic differences (Dickens and Flynn 2001), or even earlier environmental ones. The beneficiaries then write about the virtues of the system, drawing on data from correlations that reflect the system their society has in part created, and encourage generations of the future to continue to do the same. They illustrate well the fundamental principle of interpersonal attraction that we tend to value and find attractive those who are most like ourselves (see, e.g., Bradbury and Karney 2019). Each generation believes that whatever

criteria they use—race, sex, religion, caste, IQ, or whatever—provides an excellent basis for establishing a true meritocracy (Gould 1981; Sternberg 1997)—and provides empirical evidence from a rigged system of socioeconomic opportunities and stratification to prove their point. Meanwhile, others and their progeny are left behind to continue the cycle across generations.

In previous work (e.g., Sternberg 1997, 2019b), I have suggested that IQ is insufficient as a measure of intelligence and that we also need to measure creative, practical, and wisdom-based skills (Sternberg 2019b, 2021). That is *not* my point in this article. Rather, my point is that whatever is used as a measure of intelligence, we should follow Flynn (2013) in emphasizing instead of levels of intelligence, rather, deployment of intelligence. In the end, what matters is what you do with your intelligence. With all the problems we have today, what the world needs is not merely more transactional deployments of intelligence that may benefit only the transactors, but also, transformational deployments that will make the world into a better place.

A reviewer of this article suggested that scientific evidence for the "transformational-transactional" distinction is lacking. However, this distinction does not relate to kinds of intelligence—to factors, information-processing components, or loci in the brain that might be teased out, respectively, psychometrically, experimentally, or neuropsychologically. Rather, the distinction refers, as the title indicates, to *deployments* of intelligence—to how people use their intelligence. Do we need psychometric or other analyses to recognize that some people deploy their intelligence to garner rewards—grades, money, an ample house, a prestigious car—and that others use it to change the world? Do we need experiments to tell us that some people make money and give little or nothing back to the world—or worse, give negatively—and that other people change the world for the better? Do we need a biological analysis to tell us that there is a difference between the deployment of intelligence of people who use their high IQs to churn financial derivatives on Wall Street, and people who use their intelligence positively and meaningfully to change the world, like Mahatma Gandhi, Martin Luther King, Jr., and Abraham Lincoln? Are we so oblivious of our environmental contexts that we prefer to find "truth" in our artificially contrived studies rather than in the world around us? We do not know what the world-changers' IQs may have been. We do know that they deployed their IQ and whatever else constitutes their intelligence to make the world a better place. I would suggest the reviewer may have it "backward." We will never know through laboratory work who uses their intelligence transformationally: For that, we have to look to contributions to the world, not to responses on contrived laboratory tasks or educational tests.

James Flynn was transformationally gifted. He also in all likelihood had a sky-high IQ. However, it was not his IQ that made him transformationally gifted. Many people with sky-high IQs merely parrot in slightly different words or with slightly different empirical studies what so many others have said and done before them. For example, the field of giftedness has been locked into the century-old Terman paradigm, with few exceptions (e.g., Ambrose 2012; Gentry et al. n.d.; Renzulli 2012). What made Flynn transformationally gifted was his willingness to question orthodoxy (see Sternberg 2018)—both the assertions of his colleagues in the field of intelligence and the prevailing presuppositions (Zeitgeist) underlying those assertions, for example, that IQ is stable across secular time and that what matters is how much intelligence one has rather than how one deploys that intelligence. His transformational giftedness was in his mindset—in the way he used his intelligence. He opened his mind as could so many of us if we just only thought to do so.

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Essay

Two Cheers for the Cognitive Irregulars: Intelligence's Contributions to Ageing Well and Staying Alive

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Abstract: Here, intelligence is taken to mean scores from psychometric tests of cognitive functions. This essay describes how cognitive tests offer assessments of brain functioning—an otherwise difficult-to-assess organ—that have proved enduringly useful in the field of health and medicine. The two "consequential world problems" (the phrase used by the inviters of this essay) addressed in this article are (i) the ageing of modern societies (and the resulting increase in the numbers of people with ageing-related cognitive decrements and dementias) and (ii) health inequalities, including mortality. Cognitive tests have an ubiquitous place in both of these topics, i.e., the important fields of cognitive ageing and cognitive epidemiology, respectively. The cognitive tests that have sprouted in these fields are often brief and not mainstream, large psychometric test batteries; I refer to them as 'irregulars'. These two problems are not separate, because results found with mental/cognitive/intelligence tests have produced a growing understanding that intelligence and health have a reciprocal, life-long relationship. Intelligence tests contribute to the applied research that is trying to help people to stay sharp, stay healthy, and stay alive.

Keywords: intelligence; mental tests; cognitive ageing; cognitive epidemiology; mortality

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I applaud the organisers of this symposium for asking us to address world problems to which intelligence can contribute and also, "to keep this symposium totally nonideological with respect to theories of, and methods for studying intelligence . . . to take whatever theory one has, or really, no theory at all . . . The symposium also would be nonideological with regard to political issues . . . " Good—let us do that. The request gave me the relief that Winston Churchill (1898) stated when he wrote, "I pass with relief from the tossing sea of Cause and Theory to the firm ground of Result and Fact." I shall eschew the use of theory, as I explain elsewhere (Deary and Sternberg 2021); here, 'intelligence' will be represented by the scores obtained from cognitive tests *qua* readouts of brain functioning and predictors of future medical states.

Having applauded the organisers, I shall also apologise to Robert Sternberg—one of the organisers—because I turned down the invitation to write this piece a few times before accepting it. There did not seem to be much more for me to say by way of synoptic writing on intelligence; I had recently reviewed our work on the Lothian Birth Cohorts' contributions to cognitive ageing (Corley et al. 2018), I had reviewed work on the genetic and neuroimaging associations with intelligence (Deary et al. Forthcoming), I had reviewed the field of cognitive epidemiology (Deary et al. 2021), and I had massively revised/updated my wee, lay book on intelligence (Deary 2020). I had even had an extended—and good-natured—argument about aspects of intelligence with Robert Sternberg (Deary and Sternberg 2021). What else did I have to say? What eventually occurred to me was something that was closer to my medical origins—I used to be a medical doctor—rather than my adopted profession of psychology. It was that, by comparison with the sometimes-fraught topic of intelligence/cognitive testing in psychology and social sciences (why else would Warne (2020) have had to enumerate, explicate, and perhaps explode 35 myths about intelligence?), cognitive testing in medical/ageing/life-course research settings is almost omnipresent, stands usefully in line alongside other bodily assessments

(Lara et al. 2015), is often done by rinky-dink-looking tests, and appears to make a modest but useful contribution to the understanding of some important human problems.

Here are the problems: why do some people live longer than others? Of those who survive to a given older age, why do some people's cognitive functions, brains, and bodies age better than others? Longer lives are not necessarily better; the issue is that there are inequalities/differences/unfairnesses in people's longevity. Older people are not a problem; the issue is that some things happen more to older people—illness, cognitive decline, loneliness, etc.—and there are inequalities in these happenings. These issues sit alongside the facts of there being greater proportions of older people, especially in so-called developed/higher-income nations, and that people are living longer nowadays.

Note that intelligence (psychometric cognitive test scores; see Deary 2020; Deary and Sternberg 2021) has a role as both exposure/independent and outcome/dependent variables. In this piece, I want to say only three things with respect to the contribution of intelligence to the issues of cognitive ageing and cognitive epidemiology. First, the less big-headed (pun intended) intelligence appears with respect to its contribution in addressing a problem, the better I like it; that is, no human problem is likely to be explicable by a single variable, nor described by a single variable. Intelligence makes modest contributions to studying some human problems. It is good and correct, I think, when intelligence—either as an exposure or an outcome—is a modest part of a collective or recipe. Intelligence makes contributions alongside other variables. Intelligence is never the only relevant thing, nor highly predictive on its own for an individual. Second, although we cognitive scientists would advocate using well-validated and detailed batteries of cognitive tests, it is surprising how useful short cognitive assessments have been and still are. Third, in medically-oriented cohort studies, cognitive testing is widespread and used, quietly and mostly happily, alongside other assessments of bodily functioning. Having said these three things briefly, I shall now say them at greater length.

1. A Modest Contribution

Disclaimer #1: Here, I want to take a wide-angled shot of intelligence and its place alongside other factors in the important assessment of health and ageing, a bit like a class photo of cognitive testing alongside its schoolmates in human assessment rather than a close-up portrait.

I wanted to begin by getting away from any chest thumping regarding intelligence. I found an example in a modest (for those who pay attention to impact factors) journal (Nilsen et al. Forthcoming). It is a study of 674 Swedish people. It measured people's job conditions five times between the ages of 25 years and 50, assessing the extent to which the participants were in intellectually demanding work or physically demanding, hazardous/stressful work. The authors found that, by the time people were over 70, those who started in more intellectually demanding work, and who accumulated more of it, tended to have more "successful ageing". Successful ageing sounds important to me; therefore, let us look at how it was operationalised. The authors' conglomerate measure included assessments of: social activities (meeting people in different situations), cultural activities, physical functioning, cognitive functioning, and absence of diseases. The importance is not so much in the results of the paper, more that this combination of being engaged mentally and socially, sharp physically, and medically well is often used to capture healthy ageing (e.g., Lara et al. 2015); they might have added happiness/psychological wellbeing, but we sha'n't quibble.

The assessment of cognitive functioning was the abridged version of the Mini-Mental State Examination (Folstein et al. 1975; an already-short test, before the abridging), which involved immediate and delayed recall of three words; being oriented to year, month, date, country; and taking away 7 from 100 and repeating the subtraction another 5 times. That assessment of 'intelligence' would have taken just a few minutes; yet, there it was, as part of the assessment of the summum bonum of the human life course: healthy ageing. This small example made me think of two general issues with respect to intelligence/cognitive

testing and its reciprocal association with health across the human life course: the modest cognitive assessments that are often made; and the widespread embedding of cognitive tests in life-course studies.

2. Three Pages of Cognitive Testing

Disclaimer #2: Yes, of course, one can apply one of the Rolls-Royce cognitive instruments (e.g., the full Wechsler or Stanford–Binet scales' most up to date versions) to a person to obtain an assessment of their general, domain, and individual test levels of cognitive capability. Where I have been in charge of studies, I have tried to do that—using multiple tests for each of the cognitive domains—as far as was compatible with what time was available and what we thought participants would tolerate (Taylor et al. 2018). Where time has been more restricted, I have designed shorter batteries with single tests assessing important cognitive domains (Smith et al. 2012). However, oddly, the contribution of cognitive tests to the world issues of unequal longevity and unequal cognitive ageing has often been with briefer assessments. Here are three examples.

The Binet–Simon Test: An important time at which to assess cognitive functions, it was decided, when intelligence tests were invented, was in childhood; they might be used as a guide to the likelihood of an individual benefitting from a standard or non-standard educational environment. That is, some children might need more help to keep up, or some might need more stimulation if they are running ahead. As every schoolchild knows, the inventor of intelligence tests was Alfred Binet and, spread across pages 238–239 of his *Development of Intelligence* (Binet and Simon 1916)—but taking up just about one page in total (of course, the tester's instructions run to far more than that)—are the 58 questions that assess the intelligence level of every age of child from 3 to 13 years. It might not have come to much, had Dr Ovide Decroly not handed Dr Henry Herbert Goddard the sheet of paper on which the test was printed (Zenderland 1998). The Stanford revision of the Binet–Simon test was used to validate Professor Sir Godfrey Thomson's Moray House Test No. 12 (MHT) (Scottish Council for Research in Education 1933); the MHT and Binet tests correlated about 0.8. The MHT correlates (at a bit less than 0.2) with how long children live; a child with a 15-point (one standard deviation) advantage MHT score at age 11 years is, on average, about a quarter less likely to have died by their late 70s (Calvin et al. 2017). If we split the MHT scores from age 11 years into deciles, the lowest scoring decile is almost three times more likely to have died by their late 70s. Intelligence test score is neither a large nor the only contributor to survival across almost seven decades (Deary et al. 2021); however, it is remarkable that a 45-min paper and pencil test (the test is printed over five pages) of thinking skills has this predictive power for longevity.

The MoCA (Monteral Cognitive Assessment; other cognitive assessments in older age are available; quite a lot of them, actually): It is important to assess cognitive functions in older age. Low cognitive function—especially if it is declining beyond a certain trajectory—can herald dementia or so-called 'mild' cognitive impairment (Tucker-Drob 2019). Outside of cognitive pathology, lowered cognitive functions are predictors of healthy older people dealing less well with the tasks of living and being independent (Tucker-Drob 2011). Losing cognitive capability is a feared aspect of growing old. In this important setting—another contribution of intelligence to world problems—one, again, sees wide use of tests that appear on a single page (of A4 paper, or American letter size). Google 'moca test' and click images and there it is, on one page: the MoCA test, including assessments of visuospatial-executive function, naming, memory, attention, language, abstraction, delayed recall, and orientation (Nasreddine et al. 2005). It has high sensitivity and specificity in detecting cognitive impairment. It correlated 0.64 with the WAIS Full Scale Intelligence Quotient (Sugarman and Axelrod 2014). My point is not that such short scales are perfect—far, far from it; rather, it is that these remarkably short scales have a place in assessing a large clinical issue and are very widely applied. The phenomenal success of the even-shorter Mini-Mental State Examination (Folstein et al. 1975) could also be mentioned; again, you

can find that as a single-page image. The MMSE correlated 0.51 with a WAIS Full Scale Intelligence Quotient (Sugarman and Axelrod 2014).

The NART (National Adult Reading Test): We have seen that one-page (more or less) tests can usefully help to conduct the important tasks of assessing cognitive function in childhood—related to educational needs and longevity (cognitive epidemiology)—and in older age—related to possible cognitive pathology (cognitive ageing) and managing one's daily affairs. Wouldn't it be handy, though, if, in older age, and even in the early stages of dementia, it was possible to estimate what people's cognitive capabilities used to be? We know that crystallised capabilities, such as vocabulary, do not show the same decline in mean age trends as do more fluid capabilities, such as processing speed, reasoning, and aspects of memory (e.g., Salthouse 2009). However, Hazel Nelson (1982); Nelson and Willison (1991) took this a stage further. She devised a test—with stimuli printed on one page—that estimated prior peak cognitive ability; it is called the National Adult Reading Test (NART). It is based on a person's ability to pronounce fifty words that do not follow the usual rules of English language grapheme–phoneme correspondence and/or stress. It works; that is, the score on this one-page test, which takes a couple of minutes to administer, can retrodict, pretty well, prior intelligence in healthy older people. The NART, administered at age 77 years, correlated 0.72 with the Terman-Merrill revision of the Binet Test that had been administered at age 11 years (Deary and Brett 2015); yes, 68 years previously. The MHT, administered at age 11 years, correlated 0.68 with the NART administered at age 70 years, and 0.66 with the Wechsler Test of Adult Reading (the forerunner of the Wechsler (2011) Test [sic] of Prefrontal Function) (Dykiert and Deary 2013). The correlation between NART (tested at age 79 years) and MHT (tested at age 11 years) was very similar—0.63 and 0.60, respectively—in people with and without dementia (McGurn et al. 2004). It is a testament to the usefulness of the idea of premorbid/prior intelligence estimation underpinning the NART that a cognitive testing juggernaut—Wechsler–Pearson–PsychCorp—then constructed its own test based on the same idea, i.e., the Test Of Premorbid Function; a quibble is that the word 'Test' would possibly be better renamed as 'Estimator' (Wechsler 2011).

3. Fifty Million Frenchmen Can't Be Wrong

Disclaimer #3: It is optimal, probably, to do a fuller, more detailed test battery of cognitive functions; however, many, many studies from around world are showing that doing something by way of even the briefest cognitive testing is probably better than nothing. This is not an advocacy for not doing cognitive testing as well as possible; what it is is an appreciation of how, when one looks at human life-course studies, cognitive testing is almost everywhere and is trying to do a decent job of assessing something important about human brain functioning. Here, I give three examples that exemplify the cognitive footsoldiers/irregulars that occur in many studies around the world.

UK Biobank: This large population sample—admittedly non-representative of the United Kingdom's middle-aged and older population (Fry et al. 2017)—has rightly become famous for its originators' foresight in realising how informative and productive for human health half a million subjects—aged 40–70 years at recruitment and with medical, psychosocial, physiological, and genetic information—would be; oh, and with cognitive data, too. Almost all participants allowed their medical data to be collected until their death. To begin with, at their initial, approximately 90-min in-person assessment, the participants (I am one of them) took a go/no-go reaction time test and a memory test which, together, lasted just a couple of minutes. The reaction time had only four trials that counted for analysis. That makes it one more trial than in Clark Wissler's (1901) study that supposedly ended James McKeen Cattell's interest in cognitive testing; I say supposedly, because those who wrote about the study made conclusions that were not supported by its data (Deary 1994). Other overlaps between the UK Biobank's baseline assessment and Cattell's (1890) suggestion that cognitive tests would be useful if tested on large samples are the inclusion of hand-grip strength (dynamometer pressure) and immediate memory in the UK Biobank's assessments. The UK Biobank's memory test had to do with trying to

remember where, in a matrix, there were pairs of pictures of objects; there were two trials: a three by two matrix with three pairs and a four by three matrix with six pairs. For the last third of the baseline testing of the original 500,000 participants in the UK Biobank, a test called 'Fluid' was introduced. It was a test of verbal and numerical reasoning (VNR), with 13 items, and a maximum time of two minutes for completion. A few more tests were popped into the small battery at that time, and I and a colleague introduced some more later (Fawns-Ritchie and Deary 2020). I tend to veer toward more extensive cognitive batteries with longer and more diverse tests when I advise on cognitive testing in population cohorts; however, it was interesting to see how some of the UK Biobank's tests—including the two-minute fluid/VNR test—correlated with better-validated tests (Fawns-Ritchie and Deary 2020). What's my point? The UK Biobank's cognitive assessment was, originally, about as small a battery of cognitive tests as could be imagined; nevertheless, there have been many important publications based on this sample's sparse cognitive data, including: health/dementia-related studies (e.g., Calvin et al. 2019); brain structure–cognition correlation studies in older age (Cox et al. 2019); and the largest genome-wide association studies of intelligence (Hill et al. 2019; Davies et al. 2018; Savage et al. 2018; UK Biobank's genetic and small-scale cognitive data were the mainstay of all of these three, being a large majority of the human samples in each of these studies). Don't take my word for it based on the few papers I just cited; just type in 'UK Biobank cognitive' to PubMed and see how many there are, or go to the UK Biobank's publications page and type in 'cognitive' (https://www.ukbiobank.ac.uk/enable-your-research/publications), and you will find many publications including, for example, the association between baseline cognitive ability and COVID-19 mortality (Batty et al. 2021); there has been a huge payback for a few minutes' worth of cognitive testing.

The HRS Family of studies: The CANDID initiative (De Looze et al. 2021)—'Leveraging Cognitive Ageing Dementia Data from around the World'—was conducted by researchers from The Irish Longitudinal Study on Ageing (TILDA; Donoghue et al. 2018). It is an example of how community-based population cohorts of older people tend to include cognitive data as an important part of their broad, health-related phenotyping. The CANDID report included samples from China (N = 17,500+), Costa Rica (7000+), England (18,000+), Brazil (~10,000), the USA (30,000+), Japan (~4200), Korea (10,000+), India (~50,000), Mexico (15,000+), Northern Ireland (8500), Europe (27 countries contributing 140,000+), and the Republic of Ireland (8504). All included cognitive tests. The tests varied a lot, although most studies included a test of verbal declarative memory using immediate and delayed recall of items. There were, across all these studies, cognitive ability assessments including tests of global cognitive function (e.g., MMSE and MoCA), memory (five different types of tests), attention/working memory/executive function (a mixed bag, with tests including letter cancellation, visual scanning, digit span, trail making, choice reaction time, verbal fluency), numerical ability, and language skills. The long CANDID report presents the method of conducting each test and the comparability of assessments across studies; that is, for example, whether two memory tests could be considered to be assessing the same function. This moot issue was something that we tested empirically in the UK Biobank cognitive test validation sample (Fawns-Ritchie and Deary 2020).

The CHARGE consortium, etc.: This is just one example of the use of cognitive test data to examine the contribution of genetic variation to cognitive functions in mostly older people, which is a contribution to finding out what causes variation in cognitive functions in older age. In one study (Davies et al. 2018), which combined the UK Biobank with population-based cohorts from the CHARGE and COGENT consortia there were over 50 different population samples, all with cognitive testing, including samples from France, the United Kingdom (9 cohorts), Germany (4), Iceland, the USA (19), Austria (2), Greece (2), Australia (4), Sweden (4), Canada (2), Croatia (2), Republic of Ireland (2), The Netherlands (4), Finland (3), Denmark, and Norway (2). These included UK Biobank, but there was, otherwise, limited overlap with the HRS family of studies described above. These studies were included because they had at least three cognitive tests assessing different domains

of cognitive function. This meant that, for each sample, principal components analysis could be applied to examine for a general cognitive function component that was used as the 'common' phenotype across the samples, based on the finding that general cognitive components derived from different batteries tend to correlate highly (Johnson et al. 2004).

Recognising that cognitive and other bodily markers were commonly used in life course and aging studies, a group of us put together some guidelines for which ones to choose (Mathers et al. n.d.; see Lara et al. 2015 for a shorter version). The suggested biomarkers included assessments of physical, cognitive, immune, endocrine, and physiological functions. We recognised the heterogeneity of the test batteries used across many dozens of international studies, and suggested possibilities for harmonising them; do have a look at Appendix 3 of the Mathers et al. report, which lists 16 "problems and considerations in establishing cognition-related biomarkers of healthy ageing" (yes, there will probably be more than that). The CANDID report (De Looze et al. 2021) was also an attempt at harmonising cognitive batteries. A related attempt to have standard measures out there for life course studies is the NIH Toolbox, which provides a set of health-related measures including cognitive and other bodily assessments, many of which apply from age 3 to 85 years; they are brief and have undergone rigorous psychometric assessment (Gershon et al. 2013, and see the NIH Toolbox brochure for cognition, emotion, sensation, and motor measures, and do compare it with Cattell (1890): https://www.healthmeasures.net/images/nihtoolbox/NIH_Toolbox_brochure_June_2017.pdf (accessed on 1 July 2021)).

4. Conclusions

The attempt here has been to show that intelligence—in the form of the scores from cognitive assessments—has a place in looking at the differences/inequalities in people's cognitive ageing and in health differences/inequalities. It is not an argument for using quick-and-dirty cognitive assessments, although it is an appreciation of those who have usefully done so; I applaud the cognitive irregulars/contemptibles and their achievements. (One could make a similar argument—concerning the ubiquity of short measures in life-course cohort studies, alongside short cognitive tests—in other domains of testing. An exercise physiologist/physician might object that grip strength is too crude a measure of fitness, and a respiratory physiologist/physician might object that forced expiratory volume in one second [FEV1] is too crude a measure of lung function; however, both grip strength (Bohannon 2019) and FEV1 (Young et al. 2007) are used a great deal in cohort studies and are found to be useful (Lara et al. 2015).) In the spirit of 'don't make the perfect the enemy of the good', it was demonstrated how even short cognitive tests—far from the detailed batteries we psychologists would prefer to have been used—appear regularly in medical settings to do with epidemiology and geriatric medicine. Theirs is a relatively quiet presence, and they appear in medical research that perhaps does not have the heat that intelligence and intelligence assessment can generate in the more purely psychological literature. The contributions of cognitive tests are modest in these life-course/medical/ageing settings: they are neither the only exposure of interest, nor the only outcome that matters. However, as the world deals with the change in age-demographic composition, and as health inequalities are increasingly recognised, cognitive testing has been woven into the fabric of human assessments that matter. Their omnipresence, almost, in population studies evidences their usefulness. Their quiet, effective, widespread contribution to studies of health and the human life course is like that of the United Kingdom's Royal Regiment of Artillery (RA); the RA is no longer awarded battle honours and, instead, has the motto 'Ubique': everywhere.

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The Precipitous Decline in Reasoning and Other Key Abilities with Age and Its Implications for Federal Judges

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Abstract: U. S. Supreme Court justices and other federal judges are, effectively, appointed for life, with no built-in check on their cognitive functioning as they approach old age. There is about a century of research on aging and intelligence that shows the vulnerability of processing speed, fluid reasoning, visual-spatial processing, and working memory to normal aging for men and women at all levels of education; even the maintained ability of crystallized knowledge declines in old age. The vulnerable abilities impact a person's decision-making and problem solving; crystallized knowledge, by contrast, measures a person's general knowledge. The aging-IQ data provide a rationale for assessing the key cognitive abilities of anyone who is appointed to the federal judiciary. Theories of multiple cognitive abilities and processes, most notably the Cattell-Horn-Carroll (CHC) model, provide a well-researched blueprint for interpreting the plethora of findings from studies of IQ and aging. Sophisticated technical advances in test construction, especially in item-response theory and computerized-adaptive testing, allow for the development of reliable and valid theory-based tests of cognitive functioning. Such assessments promise to be a potentially useful tool for evaluating federal judges to assess the impact of aging on their ability to perform at a level their positions deserve, perhaps to measure their competency to serve the public intelligently. It is proposed that public funding be made available to appoint a panel of experts to develop and validate an array of computerized cognitive tests to identify those justices who are at risk of cognitive impairment.

Keywords: Wechsler scales; WAIS-IV; federal judges; Supreme Court; IQ; intelligence; fluid reasoning; processing speed; crystallized knowledge; working memory; aging-IQ research; computerized adaptive testing; test construction

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U. S. Supreme Court justices and other federal judges are, effectively, appointed for life, without checking potential cognitive decline. Yet, there is a century of research on aging and intelligence e.g., (Hertzog 2020; Willoughby 1927), with empirical findings showing the vulnerability of abilities like reasoning and speed to the normal aging process (Salthouse 2014a). Even the maintained ability of crystallized knowledge has been shown to decline steadily after about age 70 or 75 in cross-sectional studies controlled for educational attainment e.g., (Kaufman and Horn 1996); in cohort-sequential studies that blend cross-sectional and longitudinal methodologies (Schaie 2012); and in quasi-longitudinal studies, which follow different samples of adults over time based on their year of birth (Lichtenberger and Kaufman 2013). These findings occur for men and women, for all educational levels, and across generations (Kaufman et al. 2016).

1. The Problem

I believe that the overwhelming consistency in the literature on aging and intellectual decline should call into serious question American practices concerning the length of judicial appointments. Issues associated with the maintenance of cognitive abilities across the lifespan have been prominent for generations and are noteworthy in recent times when powerful members of the Senate and House of Representatives, presidential candidates, and presidents in both parties have been elderly, and controversy persists regarding the wisdom of lifetime appointments for federal judges.

In fact, Article III of the Constitution, which spells out the terms for all Federal Court justices (Supreme, Circuit, and District), specifies that they "shall hold their Offices during good Behaviour". According to Brian Hays, JD (Personal communication, 8 October 2021): "Though not explicitly stated in the Constitution, that clause has come to be interpreted to mean lifetime tenure for judges". The Founding Fathers might have been thinking about corruption or criminal behavior; however, a diminished capacity to solve problems and make decisions would seem to fit into the Article III guidelines.

2. The Theory

The accumulated literature on aging and intellectual development, though often not specifically inspired by theory (Hertzog 2020; Salthouse et al. 2008; Schaie 1983a, 1983b, 2012), is easily interpretable from three interdependent theoretical foundations: Raymond Cattell and John Horn's developmental theory of fluid and crystallized intelligence (*Gf-Gc* theory; Carroll 1963; Horn and Cattell 1967); Horn's (1989) subsequent expansion and elaboration of the two-pronged *Gf-Gc* theory to include a multiplicity of abilities; and John Carroll's (1993) extensive synthesis of factor-analytic research on cognitive abilities into a three-tiered hierarchical model.

Horn's and Carroll's different approaches yielded essentially the same eight to 10 Broad Abilities (the middle tier in Carroll's model), expanding the number of abilities from the original two—Fluid Reasoning (*Gf*) and Crystallized Knowledge (*Gc*)—to an array that includes Processing Speed (*Gs*), Short-term Memory (*Gsm),* Visual-Spatial Processing (*Gv*), and Long-term Storage and Retrieval (*Glr*), among others. Today, top CHC experts believe that research supports perhaps as many as 20 broad abilities, including Working Memory Capacity (*Gwm*), previously categorized as a narrow ability in the bottom tier of Carroll's hierarchy (Schneider and McGrew 2018).

The latest version of the CHC model is illustrated nicely in a figure presented by Schneider and McGrew (2018, p. 75). The figure displays 17 Broad Abilities, three of which are unconfirmed e.g., *Gh*, or Tactile Processing. It depicts three intersecting circles under the heading Acquired Knowledge: *Gc*, *Gq* (Numeracy); and *Grw* (Literacy). *Gf* and *Gwm* are depicted as slightly intersecting circles under the heading *Controlled Attention*, along with a third circle, *Gs*. Quite clearly, the latest iteration of CHC theory emphasizes the complexity of crystallized knowledge, the interaction of the diverse set of Broad Abilities, and the need to integrate these abilities to solve problems.

Although Carroll believed in an overarching general ability or *g* factor (the top tier in his model), Horn defiantly did not. Nonetheless, the three bodies of research were synthesized in the mid-1990s into a single theory, the Cattell-Horn-Carroll (CHC) model of intelligence (Schneider and McGrew 2018).

3. The Research

As noted, CHC theory provides a theoretical foundation for interpreting literature on intelligence and aging. Salthouse (2010) summarized the results of a wealth of *cross-sectional* aging data as follows:

On one hand, there is increase, at least until people are in their 60s, for measures representing products of processing carried out in the past, such as vocabulary or general information in which the relevant acquisition occurred earlier in one's life. On the other hand, there is nearly linear decline from early adulthood on measures representing efficiency or effectiveness of processing carried out at the time of assessment, usually involving manipulations or transformations of abstract or familiar material (p. 754).

These consistent findings from cross-sectional investigations of the maintenance and vulnerability of specific cognitive abilities were observed more than a half-century ago (Birren and Morrison 1961) and called the classic aging pattern by Botwinick (1977). These results generalize to a variety of instruments via an array of methodologies, such as quasi-longitudinal studies (Kaufman 2001; Lichtenberger and Kaufman 2013; Salthouse 2014a) and a merger of cross-sectional and longitudinal techniques (*cohort-sequential*; Schaie (1983b,

2012)). Baltes et al. (1999) define the two basic curves of intellectual development as the consistent negative changes in cognitive mechanics versus the preservation of *pragmatics*.

4. The "Classic Aging Pattern" Based on Cross-Sectional Analyses

Figure 1 displays the classic aging pattern with cross-sectional data on the Verbal IQ (V-IQ) and Performance IQ (P-IQ), for ages 16 to 89 years, on the Wechsler Adult Intelligence Scale—Third Edition (WAIS-III; Wechsler (1997). To enable comparisons across age groups, IQs for all adolescents and adults are compared to a reference group of 20–34-year-olds, instead of to their age peers. To try to limit the cohort effects that are inherent in cross-sectional analyses, mean standard scores of the adult portion of the sample are adjusted for educational attainment (data from Kaufman (2001)). Based on Cattell and Horn's *dichotomous Gf-Gc* theory, V-IQ corresponds to *Gc* and P-IQ to *Gf*, where the former reflects a person's acquisitions and knowledge since childhood and the latter measures the speed and accuracy of solving new problems.

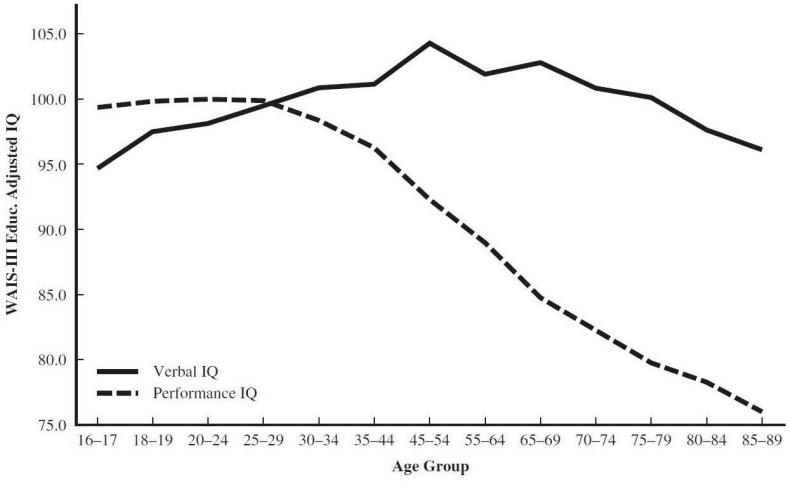

Figure 1. *Cross-Sectional Data—Age Patterns of Maintained* Vs. *Vulnerable Abilities:* Mean "Reference Group" (Ages 20–34) WAIS-III Verbal and Performance IQs, by Age, for Adults Ages 16–17 to 85–89 Years, Adjusted for Educational Attainment (Values for Ages 16–19 are Unadjusted). Source: Data are from Kaufman (2001). Figure 1 appeared in Lichtenberger and Kaufman's (2013) *Essentials of WAIS-IV Assessment (2nd ed.), published by John Wiley, on page 264 as Figure 7.3, on page 264.* Reproduced with the permission of the publisher. Copyright © 2013 by John Wiley & Sons, Inc. All rights reserved. Published by John Wiley & Sons, Inc., Hoboken, New Jersey. Published simultaneously in Canada.

When relying on modern CHC theory and its plethora of cognitive abilities—rather than on the two-pronged *Gf-Gc* model that preceded it—V-IQ and P-IQ have been shown by CHC researchers to be crude amalgams of multiple abilities. V-IQ measures *Gc*, number ability, and memory (including working memory), whereas P-IQ assesses reasoning, speed, visual-spatial processing, and dealing with novelty. The multi-factored nature of V-IQ and P-IQ is also evident from the statistically sophisticated array of investigations with different methodologies, tests, and samples conducted by Salthouse and his colleagues for more than a generation e.g., (Craik and Salthouse 2008; Salthouse 1985, 1998, 2010; Salthouse et al. 2008).

Even so, the early Cattell-Horn distinction displayed in Figure 1 is revealing. The ability to rapidly solve new problems peaks in the late 20s, plateaus briefly, and declines at the rate of about five IQ points per decade, starting in the mid-40s. By contrast, facts and

skills learned via schooling and acculturation increase to about age 60 (as long as education is controlled) before beginning its inevitable decline.

The most recent Wechsler adult scale, the 4th edition (WAIS-IV; Wechsler (2008)), relies solely on four Indexes (plus a Full Scale IQ) that align nicely with CHC theory and with the four abilities that Salthouse and colleagues have investigated, primarily using the hand-picked 16-subtest individually-administered battery, labeled the VCAP (Virginia Cognitive Aging Project; Salthouse et al. (2008)). The four VCAP abilities are essentially the same as those measured by the four WAIS-IV Indexes (Salthouse 2009).

In fact, neither Wechsler's adult scales nor the VCAP were built from a theory-based foundation, but CHC theory provides a shared vocabulary that communicates effectively to researchers and clinicians alike (McGrew 1997) and provides a useful framework for interpreting the differential age changes on the four well-researched abilities.

4.1. Longitudinal Analyses of Age Changes across the Lifespan

It is ideal to base research findings regarding aging and intelligence on longitudinal (rather than cross-sectional) studies, where the same individuals are tested over their lifetime (Hertzog 2020; Schaie 1983a, 2012). With many longitudinal studies, however, the declines in reasoning and speed are obscured because of methodological issues, especially selective attrition (low-scoring adults tend to drop out) and the profound practice effect and progressive error, particularly on nonverbal and speeded tasks (Lichtenberger and Kaufman 2013; Salthouse 2014b). Those issues compromise interpretation of data from most longitudinal studies, such as the well-known Duke longitudinal studies (Siegler 1983), in which adults were tested as many as 11 times on the original Wechsler Adult Intelligence Scale (WAIS; Wechsler (1955)).

Nonetheless, excellent longitudinal investigations of cognitive abilities across the lifespan have been conducted (Hertzog 2020), most notably Schaie's (2012) extensive series of cohort-sequential investigations in Seattle, along with other innovative studies in Victoria, Canada (Hultsch et al. 1998); Long Beach, CA (Zelinski et al. 2009); and northern Sweden (Ronnlund et al. 2005). However, definitive interpretation of patterns of decline in different cognitive abilities is contaminated in these studies (Lichtenberger and Kaufman 2013; Salthouse 2009). Statistical modeling has been used to attempt to correct for this contamination, but the effectiveness of these models is controversial (Salthouse 2009; Schaie 2009).

Schaie's Investigations. Another disadvantage of Schaie's (1983b, 2012) studies is the instrument used in all phases, namely the old group-administered Primary Abilities Test (PMA; Thurstone and Thurstone (1949)) designed for children and adolescents. Ultimately, Zelinski et al. (2009) restandardized the PMA for adults without revising it, starting in 1978. That adult standardization served as the initial impetus for the Long Beach Longitudinal Study, resulting in the development of the STAMAT (Schaie-Thurstone Adult Mental Abilities Test; Schaie (2012)).

Because the STAMAT was not revised, it had the advantage of allowing direct cross-validation of Schaie and colleagues' results with its five subtests—Verbal Meaning, Spatial Orientation, Inductive Reasoning, Number, and Word Fluency. The disadvantages, however, were considerable. As noted, the original test was developed for children and adolescents, not adults, and lacked difficult items. All tasks, even Verbal Meaning (a measure of *Gc*), were timed to balance the low ceilings; that enabled processing speed to affect the patterns of decline on all five tasks (Hertzog 2020). In fact, all tasks showed similar patterns of decline into old age, although Hertzog (1989, 2020) believed the decline for the *Gc* subtest was an artifact of its speeded nature.

Brief Overview of Findings from Longitudinal Studies. Overall, the best-designed longitudinal studies identified, "curvilinear patterns of average age changes from the period of midlife through old age, with an acceleration in the rate of aging effects on fluid intelligence, episodic memory, and spatial visualization . . . after age sixty-five" (Hertzog 2020, p. 186). The studies also demonstrated substantial cohort effects (i.e., differences in

age changes based on year of birth) on tests of *Gf* and *Gv*, but not on *Gs*, and perhaps not on *Gc*—even though *Gc* would seem to be the best candidate for significant cohort effects (Hertzog 2020).

4.2. Quasi-Longitudinal Investigations of Lifespan Age Changes

The methodological problems with longitudinal studies suggest the need to control the selective attrition, progressive error, and differential cohort effects. Consequently, quasi-longitudinal studies, which follow the same *age cohorts*, but not the same *individuals*, across generations, have advantages when examining patterns of gains and declines over time (Salthouse 2014b). Figure 2 displays these distinct aging patterns for the four Wechsler Indexes for ages 16 to 90 years, based on a quasi-longitudinal investigation of the WAIS-III and WAIS-IV (Wechsler 1997, 2008) that followed representative samples of the same age cohorts across generations. In order not to obscure age differences in these cohorts, the standard scores for *all* adults were based on a common norms group of young adults, rather than on separate age norms (Lichtenberger and Kaufman 2013).

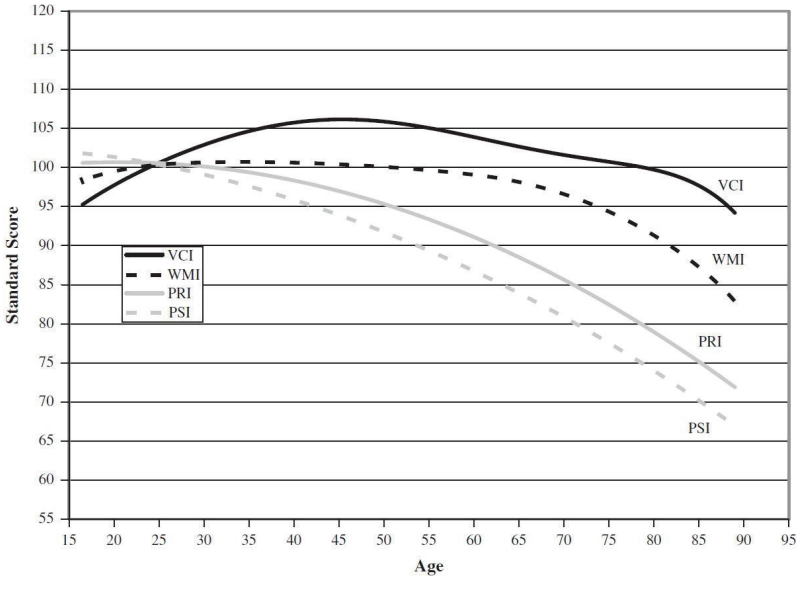

Figure 2. *Quasi-Longitudinal Data—Age Gradients for the Four WAIS-IV Indexes* Based on Mean Scores Earned by the 11 Cohorts when Tested in 1995 on the WAIS-III and in 2007 on the WAIS-IV. Source: Data are from Lichtenberger and Kaufman (2009). Analysis results from the Wechsler Adult Intelligence Scale—Fourth Edition (WAIS-IV). Copyright © 2008 by NCS Pearson, Inc. Reproduced with permission. All rights reserved. "Wechsler Adult Intelligence Scale" and "WAIS" are trademarks, in the United States and/or other countries, of Pearson Education, Inc., or of its affiliate(s). Figure 2 appeared in Lichtenberger and Kaufman's (2013) *Essentials of WAIS-IV Assessment (2nd ed.),* published by John Wiley, on page 288 *as Figure 7.7.* Reproduced with the permission of the publisher. Copyright © 2013 by John Wiley & Sons, Inc. All rights reserved. Published by John Wiley & Sons, Inc., Hoboken, New Jersey. Published simultaneously in Canada.

In that study, the cognitive abilities of 11 age cohorts from the WAIS-III and WAIS-IV standardization samples were followed over a 12-year interval; for example, those born between 1966–1970 were about 27 when the WAIS-III was normed in 1995 and were about 39 when the WAIS-IV was normed in 2007; similarly, the 1926–1930 cohort averaged 67 and 79 years of age, respectively, at the two points in time. This procedure controls for cohort

effects but requires statistical adjustment for instrument effects (3rd vs. 4th edition) and time-lag effects (cultural change).

As shown in Figure 2, the Verbal Comprehension Index, which measures *Gc*, a maintained ability, increases through late middle age before starting its decline. By contrast, the other three Indexes are vulnerable abilities, with processing speed (*Gs*, measured by the Processing Speed Index) peaking at age $16\frac{1}{2}$. The Perceptual Reasoning Index, which measures both fluid reasoning (*Gf*) and visual-spatial processing (*Gv*), peaked in the mid-20s. All three of these abilities decline dramatically and steadily through old age. Adults ages 75 to 90, when evaluated against a young adult reference group, earn mean standard scores between the mid-60s and low 80s in reasoning and speed (more than 1 to 2 standard deviations below the mean). Most mean values for this age group land squarely in the range sometimes referred to as *Borderline Intellectual Functioning* (the 70–79 range), coined by Terman (1916) to denote the slippery slope between intellectual disabilities, "and the higher group usually classified as normal but dull" (p. 87).

For the four oldest age groups in the quasi-longitudinal study depicted in Figure 2 (i.e., ages 59.5, 67, 72, and 77 years in 1995), the mean effect sizes of the 12-year change (1995 to 2007) are as follows: Processing Speed (0.56 *SD*); Fluid Reasoning/Visual-spatial ability (0.52 *SD*); Working Memory (0.40 *SD*); and Crystallized Knowledge (0.39 *SD*) (Lichtenberger and Kaufman 2013, Table 7.9). Based on Cohen's (1988) suggested guidelines for interpreting effect sizes of difference scores, a value of 0.2 is considered small, with values of 0.5 and 0.8 denoting medium and large effect sizes, respectively. For 12-year intervals, declines are of small to medium effect sizes.

It is also of interest to examine cognitive declines over longer intervals. Based on Wechsler adult scale quasi-longitudinal data at three points in time (1953, 1978, 1995), changes over the 25-year span between 1953 and 1978 on P-IQ were examined for the four age cohorts, as were changes over the 42-year span (1953–1995). The age cohort born 1924–1933 was 24.5 in 1953, 49.5 in 1978, and 66.5 in 1995. The second cohort (1914–23) was 34.5, 59.5, and 76.5, respectively; the third (1909–13) was 42, 67, and 84; and the fourth (1904–08) was 47, 72, and 89.

The decrease in adjusted mean P-IQ was very similar for each of the four cohorts over the 25-year interval, ranging from 0.77 *SD* to 0.9 *SD*, all large effect sizes. Over the 42-year interval, the values were a virtual constant, ranging from 1.47 *SD* to 1.53 *SD*, very large effect sizes (Lichtenberger and Kaufman 2013, Table 7.7).

Though the Working Memory Index is also vulnerable to the effects of normal aging, the decline in working memory capacity (*Gwm*) is not as precipitous as the age-related decreases in reasoning and speed. These results demonstrate the separate age gradients for the CHC abilities studied extensively by Salthouse and colleagues and measured by the Wechsler Indexes. Further, the distinct age patterns shown in Figure 2 align closely with (a) results of other quasi-longitudinal studies of Wechsler's scales over intervals of 25 years (1953–1978; Kaufman (1990)) and 17 years (1978–1995; Kaufman (2001)); (b) with findings from cross-sectional studies of an array of instruments over several generations (Kaufman et al. 2016; Salthouse 2009, 2010); and (c) with the results of Schaie's (1983b, 2012) cohort-sequential investigations of the PMA and STAMAT. These consistent results indicate that a theory that allows for multiple abilities, such as CHC or Thurstone's (1938) PMA model, is needed to explain the nuances of the cognitive aging process; a dichotomous model, such as *fluid-crystallized*, *Verbal-Performance*, *vulnerable-maintained*, or *cognitive mechanics-pragmatics* is too simplistic.

4.3. Age Changes in Abilities for Different Levels of Education

These investigations of changes in intellectual abilities from late adolescence to old age evaluated *group* differences, to be sure, and the data are largely based on heterogeneous samples that span the wide range of intelligence from intellectual disabilities to extreme giftedness. By contrast, federal justices are a more elite, educated group, and the results of research on aging across the lifespan by occupation or education is voluminous and

subject to varied interpretations. Studies of elderly eminent academics versus elderly blue-collar workers (Christensen et al. 1997)—and of old versus young Berkeley professors (Shimamura et al. 1995)—showed similar patterns of decline in old age. However, disputes reign. Some teams of investigators have concluded that higher education is "protective" against cognitive decline in old age e.g., (Arbuckle et al. 1998); others disagree (Anstey and Christensen 2000).

More recent analysis of data from Wechsler's adult scales supports two basic findings: (a) that more educated adults *outperform* less educated adults on all sorts of cognitive tasks, but (b) the *rate of decline* across the lifespan is essentially the same for all education levels. That finding was endorsed unequivocally on Wechsler's scales, often considered the gold standard of intelligence, based on multiple regression analyses conducted on three generations of Wechsler's adult scales (Kaufman et al. 2016).

4.4. Implications of the Body of Aging Research

Taken together, the declines in key cognitive abilities for the elderly shown in Figures 1 and 2 impact a person's executive functioning in areas such as judgment, decision-making, problem solving, concept formation, attention, memory, concentration, and planning ability (Flanagan et al. 2013, Table 3.6). This set of skills bears an intuitive relationship to the diverse kinds of real-life problem solving and effective processing of in-depth information required to be an effective, intelligent judge. Further, some researchers argue that coping with the challenges of complex occupations throughout adulthood, such as performing the job functions as a federal judge, helps maintain an adult's cognitive abilities through old age (see Krampe and Charness (2018), for a review). If so, then judges who show substantial decrease in their intellectual abilities, despite the enhancing effect of their life's work, are noteworthy. Decline in these abilities is likely to negatively affect their continued job performance. Further, there are a number of other tests that need to be considered for the proposed battery based on modern CHC theory (Schneider and McGrew 2018). Additionally, Ackerman's (2018, 2020) compelling decades-long research on expertise provides an empirical foundation for developing a criterion measure for validating the new set of computerized tests.

One thing is for certain: The accumulated group data—as compelling as they are for adults in general, including highly educated adults—do not generalize to any particular individual at any specific point in their lifetime. For that information, each adult must be assessed on reliable and valid tests to determine their current levels of functioning in key cognitive domains.

5. The Proposed Solution

I propose that public funds be made available to set up a bipartisan team of Test Research and Development Experts (TRADE), composed of prominent test developers, psychological researchers and theorists, methodologists, statisticians, clinical neuropsychologists, neuroscientists, neurologists, psychiatrists, clinical psychologists, lawyers, retired judges, historians, political scientists, and software engineers: (a) to develop a computerized test battery to evaluate the cognitive abilities and academic skills of all federal judges (Supreme, Circuit, and District) who are either currently on the bench or newly appointed to it; (b) to develop a computerized test of judicial competence to serve as a criterion measure to validate the battery of cognitive tests; and (c) to follow the test development phase with a rigorous validation stage to determine the effectiveness of the new test battery for identifying those judges who may no longer be able to fulfill their duties intelligently.

In the opinion of Thomas Dillon, PhD, who served in the Commerce and Energy Departments in the 1970s and 1980s during Republican and Democratic administrations: "The prospect of testing that could reliably assess the impact of aging on an individual's intelligence opens up a spectrum of very exciting options for application to public service . . . I really do believe that the country is ripe for such an approach as the public views a

federal government that appears to be rife with octogenarians" (Personal communications, 5 December 2020 & 15 October 2021).

5.1. SMART—A Government—Funded Precedent

There are precedents for research programs sponsored by the federal government. The U. S. Office of the National Director of Intelligence includes, among its programs, Strengthening Abstract Reasoning and Problem-solving (SMART; Kyllonen et al. (2019)). The goals of SMART are to develop tests for high-ability people and then try to validate interventions to improve the agents' abstract reasoning and critical problem-solving ability. These goals are entirely consistent with the aims of the TRADE panel I am proposing. The defense department has been applying intelligence theory, including the CHC model, to enhance the cognitive abilities of their intelligence agents (Schneider and McGrew 2018). Why not also provide funding to identify those federal judges whose abilities might be declining?

5.2. Initial Roles of the TRADE Panel—Developing and Validating the Tests

Limited competence in crystallized knowledge, processing speed, fluid reasoning, and working memory casts doubt on a judge's capacity to serve the public intelligently, or to continue in that service. However, that hypothesis must be validated before the tests are put to use, just as any new test requires validation before it is used for any type of decision-making. The panel is deliberately composed of an array of experts from diverse fields to allow preliminary discussions to be wide ranging and to blend expertise in psychological theory and research with expertise in legal and judicial matters. The dialogue among experts needs to address, and attempt to resolve, one fundamental question prior to any actual test development: Are the abilities proposed for the test relevant for the duties, responsibilities, and complex decision-making required of judges?

Further, the test development team should investigate other abilities for inclusion in the new battery. The four abilities featured in Figure 2 have a broad base of research to support their characteristic patterns of growth and decline across the lifespan. But other well-researched abilities and academic skills also deserve consideration (Schaie 2012; Schneider and McGrew 2018), and should be discussed regarding the degree to which they are relevant to a judge's competent job performance. These additional abilities would extend to real-world skills—such as wisdom, practical intelligence, overcoming first-level perceptions, inhibition, and adaptation to the environment (Gluck 2020; Kahneman 2011; Sternberg 2019, 2020)—that are not included in traditional IQ tests but are clearly pertinent to a judge's capabilities, perhaps even more so than IQ or CHC abilities.

The important question for the methodologists, psychological theorists, test developers, and software engineers on the expert panel to debate is the feasibility of developing reliable and valid psychometric tests of these clearly important aspects of intelligence. If the answer is even "maybe", then the time and money should be budgeted during the test development phase to try to reliably measure one or more of these highly relevant domains. The ultimate goal of the program is the validity phase to determine if this new test can accurately tap into a judge's capacity to remain on the bench for their lifetime.

As noted, the extensive research on expertise conducted by Ackerman (2018, 2020) and his team offers insight into the development of a test of judicial knowledge to measure the facts and skills that legal experts deem essential to a federal judge's competent performance on the bench.

5.3. Subsequent Roles of the TRADE Panel—Setting Up Guidelines for the Tests

The TRADE panel would identify the most robust statistical procedures to set the criteria for passing or failing the new battery of tests, based on analysis of a plethora of reliability and validity data gathered during the two phases of the research program; They would also decide what range of scores is deemed indeterminate, based on errors of measurement and patterns of strengths and weaknesses on the test battery. However, the

data would be balanced by the expert opinions of panel members, especially those who specialize in psychometrics, clinical neuropsychology, the law, and the judiciary. There is no simple or absolutely correct way to set the cut scores. However, the cut score for each test needs to identify those with extremely poor functioning in that cognitive ability. This is high stakes testing and the outcome of the testing has vital consequences for the individual judge and for the federal judiciary.

Absent a consensus among the TRADE panel members, my recommendation would be to use a cut-score, for each separate test, that is 2 standard deviations below the mean, corresponding to a standard score of 70 and a percentile rank of 2. I would also suggest that a judge must score below that cut-score on at least two of the tests, perhaps three.

Further, all cut-off scores for the component tests would be banded by 95% confidence intervals to ensure that no one is penalized for missing the cut by one or two points. That same level of confidence is used to determine whether death row criminals are intellectually disabled, a diagnosis that would exempt them from capital punishment (i.e., an IQ range of 65–75 is applied, rather than a simple cut-off of 70) (Polloway 2015).

In capital punishment cases, no one is put to death based on a single test score. The criminal's cultural opportunities, social-adaptive functioning, medical history, and family background all enter into the decision-making process. That same type of protection would be built in to the assessment of federal judges' competency. Every judge would be evaluated with the same yardstick; that is to say, cut-off ranges for each test would not vary from judge to judge, regardless of individual circumstances.

Nevertheless, there would be flexibility, not rigidity, in the process, and there would be built-in safeguards to ensure that no final decision is made without the opportunity for appeal. Those judges who are deemed, unequivocally, to fail the test battery would be asked to resign without fanfare; but they would be allowed an appeal. That appeal would be automatic whenever equity is at issue—for example, for judges from non-mainstream backgrounds, or for those who claim they need some kind of accommodation due to physical, psychological, cultural, or linguistic factors.

Those whose scores are too close to call, or who appeal the test results, would be given a thorough neuropsychological evaluation by a top-rated clinical neuropsychologist. The examiner would be selected randomly from a pool of expert clinicians, pre-approved by the bipartisan TRADE panel. The chosen examiner would conduct thorough one-on-one evaluations—using state-of-the art clinical measures of intelligence, achievement, personality, and memory—to identify those judges with dementia or any other type of cognitive impairment that would compromise their capacity to render intelligent decisions. Those judges who opt to appeal their requested resignation would be assessed with accommodations made to ensure equitable assessment for all judges from all backgrounds.

Clinical neuropsychologists who believe that the judge's low cognitive test scores are primarily the result of mental illness, a physical illness, traumatic brain injury, Alzheimer's, a personality disorder, and the like, are obligated to refer the judge for further evaluation. That referral might be to a clinical psychologist, neurologist, psychiatrist, gerontologist, or any other relevant professional who might provide a more definitive diagnosis. All of these professionals would either be TRADE panel members, or approved by that bipartisan panel.

The TRADE panel would determine whether to assign weights to the test results versus the psychological or medical diagnosis in deciding the judge's fate—or whether to consider the professional's verdict final and, perhaps, not subject to appeal. The panel would be responsible for determining the degree to which the public would be informed about any or all of the proceedings, either before, during, or after a decision has been made about a judge's tenure; it would also set the protocol for how frequently a federal judge would be assessed to determine their competency; whether elderly judges should be tested more often than young or middle-aged judges; how much money to compensate each judge for the time it takes for the computerized tests, and (when applicable) for the thorough neuropsychological evaluation; and how to deal with uncooperative judges who

refuse to take the test or do not give full effort during the computerized administration. In general, the panel would set all guidelines concerning test content, test security, privacy, protection from hackers, dissemination of data, and the like.

If the computerized tests prove to be valid in detecting cognitive impairment in sitting and newly appointed federal judges, and gain public approval, then the government-sponsored TRADE panel would have worldwide implications. A successful program in the U. S. would provide a test research and development prototype for other world democracies.

5.4. Questions That the TRADE Panel Must Address to Secure and Maintain Funding

In order for the TRADE program to obtain initial funding, and to continue being awarded that governmental support, the proposal for its implementation must answer, with scientific rigor, some key questions about the rationale for its proposed content and features; and whether existing technology is capable of developing reliable and valid computerized tests. Some of the more important of these questions are addressed in the sections that follow.

5.5. Isn't a Test of Crystallized Knowledge Sufficient?

Some might contend that only one test is needed for evaluating a judge's intellectual capacity, namely *Gc*. They might argue that high scores on tests of crystallized knowledge should be adequate to justify the retention of a judge, regardless of their levels of functioning on other abilities such as *Gf* and *Gs*. However, there are compelling arguments against that contention.

Gc Does Not Even Provide an Adequate Measure of Acquired Knowledge. First, *Gc*, as measured on IQ tests, assesses a person's general knowledge base and language skills (Ackerman 2020). Schneider and McGrew's (2018) overview of the modern CHC model indicates four key components of Acquired Knowledge: (a) *Gc,* defined as Verbal Comprehension + General Knowledge; (b) *Gq*, or Numeracy; (c) *Grw*, or Literacy; and (d) tests of domain-specific knowledge (*Gkn*), such as expertise in jurisprudence, biology, or opera. *Gc*, by itself, is not a thorough measure of a person's knowledge accrued via formal and informal education, training, job experience, and acculturation.

Based on an accumulation of research studies over the past 35 years, Ackerman's (2018, 2020) team has provided much evidence that *Gc*, as measured by IQ tests, greatly underestimates the knowledge base of adults; it excludes the specific areas of expertise that each adult has personally acquired through their unique experience and practice. Different types of *Gc* may demonstrate distinct cross-sectional aging curves, depending on the type of knowledge being measured (Ackerman 2020; Hertzog 2020). Ackerman (2000, 2020) and his colleagues e.g., (Beier and Ackerman 2005, in particular, have extensively researched the construct of expertise; they have studied the specific kinds of crystallized knowledge that adults learn during their lifetimes, often related to their occupations, interests, and hobbies. This type of expert or *declarative* knowledge differs from the kinds of conventional *Gc* measured by tests of information and vocabulary, such as Wechsler's or the Woodcock-Johnson's adult scales.

Additional Measures of *Gc*. There is, therefore, a strong rationale from both theory and applied research to support the inclusion of at least two separate measures of acquired knowledge in the test battery: traditional *Gc* as measured by IQ tests; and a *Gkn* test that assesses the declarative and procedural knowledge that is demonstrated to be a valid measure of a judge's specific set of facts and skills that are deemed essential to being competent and successful in performing the varied roles of a federal judge.

Numeracy and Literacy. Quantitative Knowledge (*Gq*) is another CHC ability that merits inclusion in the new test battery. *Gq* is "*the breadth and depth of declarative and procedural knowledge related to mathematics* . . . For a complex society to function, most adults must have mastered core numeracy skills . . . To provide public services and to guide public policy, a sizeable proportion of the population must also understand the basics of algebra,

geometry, and statistics" (Schneider and McGrew 2018, p. 123, italics in original). A test of *Gq*, usually found to be a vulnerable ability, has been studied extensively by Schaie (2012) and other researchers e.g., (Kaufman et al. 1996; Kaufman et al. 2008; Kaufman et al. 2009; McArdle et al. 2002); *Gq* should be considered for the new test battery.

So, too, should a test of reading comprehension, to round out the measures of acquired knowledge. Reading decoding and reading comprehension (both aspects of *Grw*) have been shown to be maintained and vulnerable, respectively (Kaufman et al. 2009). Reading comprehension is especially important to consider for inclusion because of the heavy reading burden of judges (even with a roomful of clerks to carry much of the reading load); the fact that it requires a good amount of inferential reasoning; and its vulnerability to the aging process. To increase the relevance of the reading comprehension test, the passages would reflect the kinds of documents a judge would ordinarily be expected to read, such as law briefs, previous Supreme Court decisions, case files, *ex parte* decisions, and the like.

5.6. Won't Multiple Tests of Acquired Knowledge Suffice to Evaluate a Judge's Competency?

The short answer is "No". Even reliable and valid measurement of *Gc*, *Grw*, *Gq*, and *Gkn* are not sufficient to evaluate a federal judge's competence to stay on the job for life. Assessing multiple aspects of acquired knowledge, no matter how thorough the tests, is simply not enough to make an informed decision. In order to apply a judge's range of acquired knowledge to solve complex real-world problems and to make high-level decisions, they need intact fluid reasoning.

Reciprocal Relationship Between *Gc* and *Gf*. Importantly, and historically, *Gc* and *Gf* have been shown to be interdependent e.g., (Beier and Ackerman 2005; Carroll 1987; Hambrick and Engle 2002). To summarize that reciprocity:

> Fluid reasoning creates new knowledge, and via memory, knowledge accumulates; today's fluid insights become tomorrow's crystallized knowledge . . . [;] crystallized knowledge provides conceptual structures on which new fluid insights are likely to occur. . . . This is one of the reasons why experts absorb new information related to their discipline more quickly than information unrelated to their expertise (Schneider and McGrew 2018, p. 92).

6. Interdependence of *Gf*, Working Memory Capacity, and Processing Speed

Further, *Gf* is heavily dependent on both *Gwm* and *Gs*. To perform well on tests of *Gf*, success depends on one's ability to handle and integrate abstract relationships between increasingly complex sets of stimuli. To juggle the elements of a problem, and to keep the key elements in one's immediate awareness, require excellent working memory capacity, namely "*the ability to maintain and manipulate information in active attention*" (Schneider and McGrew 2018, p. 97, italics in original). Quite evidently, *Gf* seems to depend quite heavily on *Gwm* (Shipstead et al. 2014).

Gs "*is the ability to control attention to automatically, quickly, and fluently perform repetitive cognitive tasks* (Schneider and McGrew 2018, p. 108, italics in original). Speed is not particularly important in the early, learning phases of skill acquisition—at least compared to *Gf* and *Gc*—but it is an essential predictor of skilled performance once people have learned the basic task and are seeking to develop expertise (Schneider and McGrew 2018). In view of the very rapid decline of *Gs* with increasing age, the assessment of the ability to control attention and process information automatically emerges as a potentially important test to evaluate a federal judge's continued success on the job, particularly in a rapidly changing society.

6.1. Should Fluid Intelligence and Visual-Spatial Reasoning Be Separate Tests?

Salthouse and his colleagues originally studied five abilities, not four, when they began their research program; visual-spatial reasoning (*Gv*) and *Gf* were analyzed as separate abilities. However, Salthouse et al. (2008) ultimately merged *Gf* and *Gv* into a single ability, labeled *Fluid Reasoning*, because *Gf* and *Gv* correlated highly and displayed the

same vulnerability to aging. Yet, for evaluating a judge's continued ability to perform at a high level, *Gv* could easily be a stand-alone test that differs from "pure" *Gf* in the kinds of problems to be solved. Schaie (2012) and Zelinski et al. (2009), in fact, evaluated *Gf* (Inductive Reasoning) and *Gv* (Spatial Orientation) as separate measures in their comprehensive blend of cross-sectional and longitudinal investigations.

Wechsler's adult scales across generations are also noteworthy regarding the separation of *Gv* from *Gf*. These two CHC abilities have historically been tethered in Performance IQ ever since Wechsler (1939) published the Wechsler-Bellevue Intelligence Scale. That amalgam continued with the publication of the WAIS (Wechsler 1955) and its revisions (Wechsler 1981, 1997, 2008)—including its 4th edition—as either P-IQ (see Figure 1) or the Perceptual Reasoning Index (see Figure 2). The blending of *Gf* with *Gv* characterized the Wechsler Intelligence Scale for Children (WISC; Wechsler (1949)), as well, through the 4th edition (Wechsler 2003).

By contrast, the 5th editions of Wechsler's scales yield five—not four—primary indexes with *Gv* and *Gf* measured as distinct abilities (Wechsler 2014, 2021). The separation of these two problem-solving abilities is also featured in other popular clinical tests of intelligence (Kaufman and Kaufman 2018; Schrank et al. 2014), consistent with modern CHC theory (Flanagan et al. 2013; Schneider and McGrew 2018).

There is clearly justification from empirical research and clinical assessment for the TRADE panel to consider separate measures of *Gf* (abstract reasoning and logical thinking; e.g., Raven's matrices) and *Gv* (visual-spatial problem-solving; e.g., Wechsler's Block Design). A separate *Gv* test also makes practical sense. The ability to visualize stimuli in two- and three-dimensions, and to mentally manipulate them in space, is potentially a key skill to assess in an era that relies heavily on PowerPoint slides, graphic presentations, and a plethora of complex visual stimuli that predominate on an array of websites.

However, the results of test development and validation research conducted by the proposed TRADE panel would need to determine whether separate tests of *Gf* and *Gv* are warranted. Similarly, the panel would need to determine precisely which tests, and how many, should be included in the test development phase of the research program and, ultimately, how many to include in the final test battery after the results of the validation phase have been thoroughly analyzed and cross-validated.

The Proposed Test Battery. Based on research, theory, and real-life problem solving, I believe the following eight tests should be proposed to the panel for consideration: Crystallized Knowledge (*Gc*), Fluid Reasoning (*Gf*), Working Memory Capacity (*Gwm*), Processing Speed (*Gs*), Visual-Spatial Reasoning (*Gv*), Expertise in Jurisprudence (*Gkn*), Reading Comprehension (*Grw*), and Quantitative Knowledge (*Gq*). Further, tests of adaptive constructs such as wisdom, adaptation to the environment, practical judgment, and inhibition, and should be pursued vigorously for possible inclusion.

6.2. Should There Be a Global Score?

I also would propose that no global IQ or composite score should be computed, a specious concept at best for tests that produce unique aging patterns across abilities and adult age groups, as displayed in Figures 1 and 2. Based on data from the Woodcock-Johnson—Revised (Woodcock and Johnson 1989), McArdle et al. (2002) concluded that any model of changes in ability with age that relied only on *g* is too simplistic and misses the complexity of growth and decline over the lifespan.

6.3. Does Research Support the Use of Cognitive Tests to Predict Job Performance?

IQ has been correlated to job performance, usually supervisor ratings, for decades and decades. Literally hundreds of studies conducted through the 1960s yielded unimpressive validity coefficients in the 0.20 to 0.30 range, with considerable variability (Ghiselli 1973). Subsequent researchers reanalyzed the same data, this time correcting the values for a variety of so-called statistical artifacts such as attenuation and restriction of range, thereby doubling the validity coefficients to about 0.50 e.g., (Hunter and Hunter 1984; Schmidt and

Hunter 2003). Values in the 0.50 to 0.60 range have since been consistently reported for new samples, including workers in European countries such as Great Britain (Bertua et al. 2005) and Germany (Lang et al. 2010).

This array of studies has been praised as offering widespread support for the validity of IQ as the best predictor of job performance. Some have been lavish in their praise: "Not relying on it [i.e., measured cognitive ability] for personnel selection would have serious implications for productivity. There is no getting away from or wishing away this fact" (Ones et al. 2005, p. 450).

However, the uncritical high praise commonly given to the consistent results of a great many meta-analyses, does not stand up to careful scrutiny. Critical study-by-study interpretation of the methodologies are sobering and compelling e.g., (Richardson and Norgate 2015). Many criticisms are right on target: (a) correction for attenuation, that is to say for the fact that tests are not perfectly reliable, is neither standard practice nor justifiable; (b) supervisor ratings are notoriously unreliable; (c) meta-analyses have merged data on dozens of IQ tests, aptitude batteries, tests of working memory, and the like as if they are all comparable measures of *g*; and (d) many studies are from the military, which may not generalize to the typical workplace.

The literature, therefore, offers only mild support for the use of cognitive tests to predict job performance. However, the serious criticisms of previous studies can be addressed. The use of general intelligence as a predictor defies contemporary theory and practice, both of which tend to focus on multiple cognitive abilities. Further, CHC theory and research provide rationales for measuring an array of specific abilities that are likely to be related to the complex job functions of a judge. And, perhaps most importantly, it should be feasible for the TRADE panel to develop a reliable and valid criterion of a judge's many job functions.

6.4. What Criterion Would Be Used to Evaluate the Validity of the Tests?

One of the eight proposed tests would provide an excellent, reliable criterion to evaluate the validity of the other seven tests—namely, the measure of *Gkn* that assesses expertise in jurisprudence. The lawyers, retired judges, political scientists, and historians on the research panel would contribute to the development of this specialized test of judicial expertise. Content would include knowledge and skills specific to jurisprudence, acquired by both procedural memory and episodic memory; the test would be targeted for all judges—whether federal, state, or local—but its primary focus would be at the federal level. Whereas the relevant members of the TRADE panel would assist in formulating the test's content, the main thrust for developing and validating this specialized test of *Gkn* would be true experts. In particular, I would recommend that current and former law clerks for federal judges would be the ideal experts for identifying the range and breadth of test content. They will have had firsthand knowledge of the extensive sets of facts and skills necessary to perform the complex and varied job functions of a federal judge. These esteemed professionals would be asked to participate in a structured interview to help provide the essential content for the criterion measure of judicial expertise. TRADE panel members would develop the survey questions and conduct the interviews. The validity of the *Gkn* test itself would derive from the unparalleled authority of the law clerks, and from statistical analyses e.g., (exploratory factor analysis, confirmatory factor analysis, logistic regression analysis) conducted during the development and validation of all tests in the new battery.

Regarding federal law clerks, Brian Hays, JD (Personal communication, 9 October 2021), offered the following regarding the potential number of clerks in the pool:

> My friend and classmate, Jim Bird, clerked for Judge Skelly Wright of the DC Circuit Court of Appeals in 1977–78, then went on to clerk for Supreme Court Justice William Brennan in 1978–79. He said that in a typical year there are 30 to 37 clerks for Supreme Court Justices. The number of living Supreme Court clerk 'alumni' is therefore perhaps 1000, but no more than 1500. Further, there are

around 800 federal judges in the lower courts (Circuit and District) and most of the time, these judges also have clerks. Altogether, the pool of living law clerks probably exceeds 10,000 and might be closer to 20,000. A number of former federal clerks stay in touch. Jim went to a reunion right before the pandemic.

But law clerks are only one of many groups needed to develop and validate the measure of judicial expertise. Samples with differing levels of knowledge about judicial procedures would be tested, for example, lawyers, accountants, physicians, politicians, retired judges, political science professors, and active judges at the state or local level. Test scores on the measure of *Gkn* for the diverse samples would be compared; so too would validity coefficients for each sample to help establish convergent-discriminant validity.

6.5. Would Judges Who Earn High Scores on the Criterion Measure Be Required to Take the Remaining Cognitive Tests?

No, that would defy logic. The test of judiciary expertise would be the first test administered. Judges who "pass" the criterion should not be required to take any of the predictors of that criterion. If we have the answer, we don't need to ask the question.

The challenge is to determine the appropriate cut-off point to identify competency. Again, expert input, especially from current and former federal law clerks, would be instrumental in making that decision. The validation samples for the *Gkn* test would provide empirical input to blend with expert opinions. In particular, validation samples comprised of retired federal judges, current or retired state and local judges, legal experts on judiciary matters, and so forth, might be instrumental in helping set the cut score. Ideally, that cut score, banded by a 95% confidence interval, would determine which federal judges would be required to take the remaining cognitive tests.

6.6. What Kind of Norms Should Be Used to Determine a Person's Scores?

By convention, every individual's scores on IQ tests are based on their age peers. Nine-year-olds are compared to other 9-year-olds to compute their IQs; 17-year-olds are compared to others the same age; 22-year-olds are compared to their age peers (20–24); and so forth through the lifespan with the IQs of 88-year-olds compared to a group of 85–89-year-olds.

For these new tests, I would propose to the TRADE panel that conventional standardization techniques should be abandoned. I favor basing everyone's standard scores on stratified random samples of all adults (from young adulthood through old age) rather than on the performance of their age mates. The long-time clinical practice of basing an adult's scores on their age peers obscures the effects of aging and is inconsistent with the fact that adults, in the real world, compete with each other, regardless of age.

Wechsler made the decision to base children's and adults' IQs on their age-mates when he first published the Wechsler-Bellevue Intelligence Scale (Wechsler 1939) for ages 7 to 69 years. That decision has always made total sense for children, adolescents, and even young adults, all of whom are undergoing rapid intellectual development and are steadily gaining knowledge from elementary school, high school, and perhaps college. But that decision has never made sense for adults who are striving to enter graduate schools or technical schools; who are running for public office; who are seeking entry into a craft; who are applying for an industrial position or a training program or are competing for a promotion while climbing the business ladder; or who are actively engaged in most any group activity within a competitive society.

Wechsler (1939) added to the confusion by basing scaled scores, on the 10 or so subtests, on a reference group of young adults (ages 20–34) for *all adults* regardless of age; but then he opened up a can of worms when he opted to base their IQs on their age peers. For many elderly individuals, the subtest scaled-score profile might reveal scores averaging 7 or 8, when compared to the reference group of young adults (16th to 25th percentile); but alongside those scaled scores would be IQs that ranked them at the 50th or 60th percentile, based on the performance of their age group.

This discrepancy between scaled scores and IQs was confusing to clinicians, especially when trying to explain the results to family members or educational and medical personnel at feedback conferences. Wechsler's decisions about reference groups were made more than 80 years ago and were arbitrary; yet that practice has endured to the present day.

Certainly the competency of federal judges is relative to other judges, whether they are 45 or 75; and the standard of competency does not shift for elderly judges. The research panel would make the ultimate decision of the best type of norms to use and what age range to include in an all-adult sample. My vote, if I had one, would be to base scores—for adults of every age—on a reference group that included a wide age range, such as all adults ages 21 to 99 years (or perhaps 25–99).

6.7. Do We Have the Technology to Develop the Proposed Computerized Tests?

We absolutely do possess the technology in the 21st century to develop and validate the ambitious computerized series of tests proposed in this paper. Coinciding with the accumulated literature on aging, intelligence, expertise, and CHC theory has been the sophisticated technical advances in test construction over the past two generations, most notably in (a) item-response theory (IRT), such as the Rasch-Wright latent-trait model (De Ayala 2009; van der Linden and Hambleton 2015); (b) computerized-adaptive testing (CAT; Wainer (2015)), that is to say, digitally administered tests that tailor each set of items to each person, based on their success or failure on the previous item; (c) methodologies for detecting item bias—differential item functioning (DIF; Holland and Wainer (2015); Zwick et al. (1995)); these statistical procedures help weed out items that are unfair to a particular subsample; (d) protocols for developing large banks of items for IRT-CAT designs to permit the continuous standardization of tests (van der Linden and Glas 2010); and (e) pertinent statistical and methodological Rasch-based IRT analyses, developed specifically from longitudinal data on vocabulary and memory, to deal with repeated constructs in developmental studies (McArdle et al. 2009). All of these advances make it feasible to develop CATs for the express purpose of assessing the cognitive abilities of all federal judges serving on the bench, or appointed to it, at any given point in time.

Item Banks, Continuous Norming, and IRT-CATs. Literally tens of thousands of items could be developed for the item bank, enabling the tests to be continuously revised and re-standardized to partially neutralize practice effects and eliminate the Flynn Effect (Flynn 1987, 2020). Computerized tests could be administered to thousands of Americans per month if funded by the government. Data from stratified random samples of adults could be added to the normative base and the norms could be updated at regular intervals, perhaps each week or each month, much the way ESPN updates all major league baseball statistics every day as soon as each game is completed. Older normative data e.g., (tests administered three or four months earlier) could be eliminated as new data are collected and integrated into the normative sample; that would keep the norms completely up to date from the first day it is published.

Further, the precise positioning of items in an IRT-based CAT permits great accuracy even with short tests (Sinharay 2016). The technology for designing item banks for CAT is sophisticated (van der Linden and Glas 2010; Wilson 2004), including measuring intelligence (van der Linden 2005). And there is precedent for developing thousands of items for the new cognitive tests, using the architecture underlying the automatic item generation program for math tests that can be applied to measure *Gf* (matrices), *Gc* (picture vocabulary), *Gq* (math knowledge), and other abilities as well (T. Matta, Personal communication, 2 and 9 November 2020).

Will the Flynn Effect Be a Problem? By definition, a person's score on an intelligence test is based on their performance relative to others *at that particular point in time*. The Flynn Effect demonstrates that the norms of every intelligence test are outdated in the U. S. at the rate of 3 global IQ points per decade; they are already a bit out of date the day the test published (typically about a year after the sample is complete). As test norms age, they spuriously inflate a person's IQ. In clinical practice and in courts of law, IQ points must be

subtracted from a person's obtained IQ based on how old the norms are to remove that spuriousness (Flynn 2020). The proposed continuous norming procedure totally avoids the Flynn Effect.

Equity. DIF formulas (Zwick et al. 1995) would be applied during test development phases to eliminate items biased by ethnicity or gender or socioeconomic status. However, to avoid marginalizing any person or any group, I would recommend to the TRADE panel the model used in Europe when standardizing the new tests—neither race nor ethnicity would be included as stratification variables or even recorded. I know personally, by co-authoring a test for French-speaking people, that they take a different approach to stratification variables than we do in America.

The Research Director of our French test, Dr. Louis-Charles Vannier (Personal communication, 12 November 2020) said: "In France, as in Spain, Sweden, Denmark and Norway, we don't use Race or Ethnicity when we stratify our samples. From a legal standpoint, collecting official census data about race or religious opinion is illegal—incompatible with the first article of the French constitution".

Ease of Administration. Whereas current clinical tests of intelligence can only be administered by professionals with years of supervised training, usually psychologists, the self-administered CATs can be proctored by nurses, technicians, and others who complete a brief training program. The fact that administration of these tests would not require any physician to be present raises the possibility of AMA approval for inclusion in annual physical exams.

6.8. How Might Public Awareness and Approval Be Achieved?

Dr. Dillon (Personal communication, 3 December 2020) cautions, "this testing capability will not be widely utilized unless the general public can be broadly exposed to its potential benefits". The first task of the TRADE panel would be to raise public awareness of the problem and of the science behind it. Prior to any test development, publicity campaigns would need to teach Americans about the crucial research on the decline in cognitive abilities, such as reasoning and memory, in elderly individuals, and its importance for the National interest.

Regarding specific steps to take, Dr. Dillon (Personal communication, 15 October 2021) advises:

> If a long-term, concerted effort was made to educate the media and professional organizations (ABA, AMA) it could have a huge impact via moral suasion. But it would require a very patient endurance. The moral suasion approach has huge advantages in that it fits smoothly into our political system (we love to point out weaknesses in our government leaders), and could apply to a broad scope of individuals (including federal, state and local government officials and judges). You would have to start with getting a broader group of scientists/academics to verify critical points concerning competency and to formulate a convincing and accessible statement of 2 or 3 crucial concepts for everyday people with a high school education or higher. You recruit a small group of respected scientists/academics to approach sympathetic media outlets and social media personalities to tell that simplified story. You need to keep at this stage until it goes "viral" and becomes the modern equivalent of true. Ultimately, any approach that advocates removal of federal judges is designed for an argument, a large-scale political argument, and would have to face the verdict by a significant population of voters and/or taxpayers.

Brian Hays, JD (Personal communication, 4 January 2021), a specialist in bringing scientific and technology innovations to the healthcare industry, suggests a strategy that targets physicians:

> One way to get public approval is to get the American Medical Association to adopt mental testing in annual physical exams that go beyond the current

> simplistic dementia testing. If the standard of care for general practitioners includes an assessment of reasoning capability, then reimbursement of the cost by Medicare/Medicaid would be a powerful step toward wide acceptance; applying that testing to government officials on an annual basis would not be controversial.

Hays (Personal communication, 15 October 2021), also advises directly involving lawyers to reach a broader audience:

> To get the question properly considered, the issue has to move from an academic discussion to become an issue for the legal system to consider. There is actually a well-worn path for this. The topic could first move from the scientific academic community to the legal academic community. The legal scholars can publish in various legal publications, including Law Reviews that are published by virtually every law school. If this paper is introduced to some legal scholars, there is a certainty that the issue would be publicized in the legal press; the actual legal questions are just as interesting as the scientific, social questions. A legal paper could get taken up by the federal bar association or the ABA. Much more to be desired, however, is that a Chief Judge of one of the federal Circuit Courts becomes interested. A Chief Judge has actual power to address the issue, especially if there have been instances of impairment in the Circuit in question.

6.9. Why Focus Only on Appointed Federal Judges—Why Not Demand Accountability for Everyone in Power?

In an ideal democratic nation, all candidates for public office, at every level of government from local to national, would be assessed for intellectual function and possible cognitive decline. Seven of the eight proposed tests (all but judiciary expertise, *Gkn*) are ideal assessments for any adult in public service. But for obvious political and historical reasons, the testing of a candidate's cognitive functions prior to an election or reelection campaign simply will not happen, at least in this millennium.

Hays (Personal communication, 15 October 2021) offered the following perspective on assessing the competency of anyone in power, whether an elected public official, a physician, a tenured professor, or a judge at the state level:

> The question about applicability of the competence standard to other people in power is a fair one. The brutal answer that no one really wants to hear—especially if you are 70 or older—is that every person who has some level of responsibility wider than themselves and their immediate family should be subject to these standards. In many circumstances, there are systems in existence that can be used to question competency. The medical profession (and to a lesser degree the legal profession) has established a 'standard of care' to adjudge whether the professional in question is guilty of malpractice.
>
> There is, however, a fundamentally important distinction between all professions and the situation with federal judges. The problem with federal judges is that the appointments are (in effect) lifetime appointments that have very narrow (if any) restrictions on their continuation in their guaranteed position. The check on a President or any Member of Congress—at least in theory—is that they have to stand for re-election. In theory at least (and occasionally in real life) the electorate will not return someone to office if they are demonstrably incompetent. What makes the situation with federal judges particularly acute is that there does not presently exist a realistic check on a lifetime appointment, regardless of the circumstances. As an operating principle for any functioning society, there should be consequences for actions, i.e., accountability. This is especially important in situations where the position holder has power over the life, liberty and property of someone, as a federal judge has.
>
> With judges at the state level, most are elected and, therefore, subject to some level of accountability. In the states where the Governor appoints judges, sometimes

> based on recommendations from various boards, there is usually a regular review process. Only one state has lifetime appointments for its judges—Rhode Island.

6.10. Would the New Tests Have Any Application Besides the Evaluation of Federal Judges?

Except for the test of judicial expertise, the remaining tests are suitable for any American adult. They might find useful applications for other purposes within the structure of the federal government. For example, Dr. Dillon—one of the first Presidential Appointees enabled by the Civil Service Reform Act of 1978, and a participant in both the Carter and Reagan transition teams—noted:

> Another very promising set of public officials where this testing could be exceptionally useful would be in the vetting of so-called Presidential Appointees. These range from Cabinet Secretaries to several thousand lower level officials. People being considered for such positions are routinely vetted and would likely submit to such testing if a new Administration required it as part of the vetting . . . This might be a unique window of opportunity to introduce the science of intelligence assessments into our political infrastructure (Personal communication, 3 December 2020).

6.11. Does this Proposal Reflect Discrimination against the Elderly?

The proposal certainly might appear to be promoting age discrimination, but that is not my interpretation of it. I have focused on the elderly because an array of high-quality empirical studies demonstrates an alarming decline in cognitive abilities with increasing age, especially in problem solving and processing speed. I have also targeted the lifetime appointments of federal judges because of the research-based findings on cognitive decline in the elderly. However, opposition to appointing federal judges is not new. Further, the topic is active right now as I am writing this article. The focus of the commission convened by the Biden administration is whether to add additional seats to the Court. But an additional—less dramatic, but still very important—question up for consideration is whether the Court (and by extension, the rest of the federal judiciary) should be appointed with term limits. According to Abby Phillips (2021), this notion has support among the bipartisan commission. Congress could conceivably consider a law or Constitutional change to limit the terms of federal justices.

Regarding age discrimination, the paper recommends testing *all* sitting and future federal judges regardless of their age; it also suggests applying the same pass-fail criteria for all judges. Further, the accumulated data indicate that notable decreases in cognitive test scores begin in early middle age. Figure 1 makes it apparent that nonverbal abilities start to decrease steadily and substantially at about age 40. Figure 2 highlights, more specifically, the rapid declines in reasoning and speed that begin well before old age.

The data from all aging-IQ studies are for groups. Within each group, there are broad individual differences on all cognitive abilities across the entire age range. Everyone knows brilliant men and women who are 70 or 80 or 90, including public figures such as federal judges. Also, Hertzog (2020) points out that there are important ways that people can have some say in how well they maintain their cognitive abilities: "Over the past two decades, compelling evidence has emerged that aerobic exercise in middle age and old age promotes enhanced cognitive function in older adults" (p. 196).

But regardless of political correctness or politics in general, there needs to be a check on the cognitive functioning and judicial expertise of any person who makes high stakes decisions, especially judges who are, in effect, appointed for life.

6.12. Is the Proposal to Evaluate the Competency of Federal Judges Legal?

To address this key practical issue, I consulted Thomas Dillon, PhD, and Brian Hays, JD, both of whom possess relevant backgrounds and pertinent experience.

Thomas Dillon (Personal communication, 8 October 2021):

> Your proposal would be legal if the Congress passed a law to establish such a procedure for removal of federal judges. However, such a law would need to be judged constitutional, and there is no guarantee of that happening. The best chance would be to pass a law that would use your process as a legitimate basis for impeachment. The Constitution's only requirement for term of office for all federal judges—Supreme, Circuit, and District—is good behavior. You could claim that your tests could prove that judges no longer had the capacity for good behavior; but even that law would face a political battle regarding its constitutionality and ultimate implementation. So, yes, your proposed process has a pathway to be declared legal and constitutional, but not an easy one".

Regarding impeachment, Dr. Dillon added, "And, yes, the complicated political process of impeachment would be required. Although, it is important to note that all 8 impeachment convictions were of federal judges" (Personal communication, 9 October 2021).

Brian Hays (Personal communication, 8 October 2021) noted that "passing a law, or a constitutional amendment, are two difficult ways to implement a TRADE program. However, there are other less dramatic and vastly more practical ways to accomplish the goal of pushing toward solid mental capabilities in the federal judiciary".

Hays explained:

> From the point of view of the American federal legal system, the issue is not whether some judges are impaired; the issue is what to do about it. The legal issues are daunting, but there are options that can sidestep the most formidable ones. For example, your concept of a TRADE process would fit in very well in the existing Circuit Judicial Council structure. The Chief Judge has a very broad set of actions that he or she could take to deal with a situation when the TRADE panel determines that a judge is impaired. If the judge in question refuses to resign or even go on to Senior status after gentle prodding, the Chief Judge of a circuit and/or the Judicial Council could effectively remove a federal judge (District or Circuit Court, not Supreme Court) without getting anywhere close to a Constitutional issue—provided the judge in question is allowed to retain their position and salary, but is assigned no cases to adjudicate.
>
> Note that federal judiciary funding is provided by Congress; it would be appropriate for Congress to authorize TRADE funding as part of the annual appropriations process. Note, also, that to trigger the 'good behavior' clause of the Constitution in the situation of Supreme Court Justices, the mental impairment would have to be extreme (Personal communication, 9 October 2021).

7. Final Thoughts

CHC is but one theory of intelligence and cognitive tests are only one way of measuring a person's intelligence and competence—and an incomplete way at that. As alluded to previously, Robert Sternberg's (2020) augmented theory of successful intelligence goes beyond psychometric tests and includes creativity, practical intelligence, the ability to capitalize on strengths to compensate for weaknesses, and the notion of wisdom, all for the purpose of serving the common good via ethical values; his theory of adaptive intelligence (Sternberg 2019) focuses on adaptation to the environment and finding solutions to real-world problems like pollution, global warming, and poverty. Also, Daniel Kahneman's (2011) life's work, theories, and integration of research focus on the psychology of judgment, decision-making, overcoming first-level perceptions and biases, self-regulation, and inhibition. In his latest book, Kahneman et al. (2021) argue that in any process that includes judgment, noise is inherent. They specifically discuss the variability in determining sentences imposed by federal judges for convicted criminals.

Sternberg's and Kahneman's theories and research address political competence and practical solutions to real-world problems, and these attributes of intelligence are only partially measured by standardized tests of cognitive ability. As discussed earlier, the

TRADE panel needs to affirm that the abilities proposed for the new set of tests are relevant to a judge's competence, and they must develop a reliable and valid criterion measure of judicial expertise. Also, they should carefully consider developing additional tests that are pertinent to a judge's job performance, especially the kind that measure the real-life abilities and skills studied by theorists and researchers such as Sternberg and Kahneman.

Though necessarily incomplete as measures of all of intelligence, the psychometric CHC theory and the research it has spawned provide the scientific foundation for moving forward with the identification of those federal judges who should undoubtedly be urged to resign rather than serve for the rest of their lives. There is strong empirical support for predictable, and differential, changes in key cognitive abilities between young adulthood and old age, a body of research that I believe runs contrary to lifetime appointments for Supreme Court justices and other federal judges. We also have access to advanced technology for the development of reliable and valid computerized tests, administered remotely if necessary (Wright and Raiford 2021; Wright 2020), to assess these abilities. It is now time for a bipartisan movement across the U. S. to put psychological science into action.

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The Transition to Noncommunicable Disease: How to Reduce Its Unsustainable Global Burden by Increasing Cognitive Access to Health Self-Management

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Abstract: The global epidemic of noncommunicable diseases (NCDs), such as cardiovascular disease and diabetes, is creating unsustainable burdens on health systems worldwide. NCDs are treatable but not curable. They are less amenable to top-down prevention and control than are the infectious diseases now in retreat. NCDs are mostly preventable, but only individuals themselves have the power to prevent and manage the diseases to which the enticements of modernity and rising prosperity have made them so susceptible (e.g., tobacco, fat-salt-carbohydrate laden food products). Rates of nonadherence to healthcare regimens for controlling NCDs are high, despite the predictable long-term ravages of not self-managing an NCD effectively. I use international data on adult functional literacy to show why the cognitive demands of today's NCD self-management (NCD-SM) regimens invite nonadherence, especially among individuals of below-average or declining cognitive capacity. I then describe ways to improve the cognitive accessibility of NCD-SM regimens, where required, so that more patients are better able and motivated to self-manage and less likely to err in life-threatening ways. For the healthcare professions, I list tools they can develop and deploy to increase patients' cognitive access to NCD-SM. Epidemiologists could identify more WHO "best buy" interventions to slow or reverse the world's "slow-motion disaster" of NCDs were they to add two neglected variables when modeling the rising burdens of disease. The neglected two are both cognitive: the distribution of cognitive capacity levels of people in a population and the cognitive complexity of their health environments.

Keywords: intelligence; functional literacy; job complexity; nonadherence to treatment; noncommunicable disease; diabetes; diabetes self-management; behavioral risk factors; global burden of disease; epidemiological transition

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1. Modern Life Is Becoming Ever More Cognitively Complex

In his essay, "The Evolution of Idiots," humorist Scott Adams (1996) describes how "a few thousand amazingly smart deviants" created a world that turned the rest of us into ninnies. We were pretty much doomed, he says, after "some deviant went and built the printing press . . . . Civilization exploded. Technology was born. The complexity of life increased geometrically. Everything got bigger and better. Except our brains".

Adams captures perhaps the most pervasive but least appreciated influence that general intelligence, the latent trait (phenotypic *g*), has on modern life: the recurring wide variation in *g* within human populations gradually reshapes a culture as advances in technology ratchet up the cognitive complexity of everyday life (Gottfredson 1985). In so doing, successive innovations make differences in cognitive ability more salient. They begin to "ninnify" most everyone, but especially individuals of lower or declining capacity, because they are less able to capitalize on their culture's new benefits and avoid its new hazards.

My specific concern is that, with advances in treatment regimens for noncommunicable diseases (NCDs), health care providers are unknowingly placing cognitive burdens on

patients too heavy for many to bear. Cognitive overload precludes adherence to NCD treatments, which patients themselves must implement to stave off predictable complications and premature death. Healthcare providers are vexed and public health officials alarmed by high rates of nonadherence. The major NCDs—heart disease, stroke, cancer, diabetes, and chronic respiratory disease—are epidemic worldwide, their morbidity and mortality steadily rising, and their costs becoming unsustainable for rich and poor countries alike: a global "slow-motion disaster", warned the WHO (Chan 2017, p. 91). I use adult literacy data to explain why NCDs are so difficult to self-manage and suggest tools that the healthcare professions can develop and deploy to increase patients' cognitive access to NCD self-management (NCD-SM). I also suggest how epidemiologists can incorporate cognitive risk in their models to identify "best buys" (World Health Organization (WHO) 2017) for controlling the global burdens of NCDs.

2. Noncommunicable Diseases (NCDs) Now Cause More Disease, Disability, and Death Globally Than Do Infectious Diseases

Figure 1 shows the remarkable global progress in eliminating the pestilences that killed people en masse in earlier millennia, including malaria, yellow fever, smallpox, and cholera. Deaths from communicable diseases fell swiftly after global immunization and clean-water campaigns were launched in poorer countries in the late 20th century, as they had fallen in richer countries earlier in the century (Centers for Disease Control and Prevention (CDC) 1999). During 2000–2019 alone, the crude death rate (CDR) was almost halved in countries the World Bank classified as low income in 2019 and cut by 25% in the lower-middle income country group (Panels a, b), both their CDRs dropping well below that of aging high-income countries. Life expectancy at birth increased in all country groups, but increased most—by over 11 and 7 years—in the two lowest income groups as infant mortality and deaths from diarrheal diseases plummeted (WHO GHO database, https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-leading-causes-of-death (accessed on 5 December 2021)).

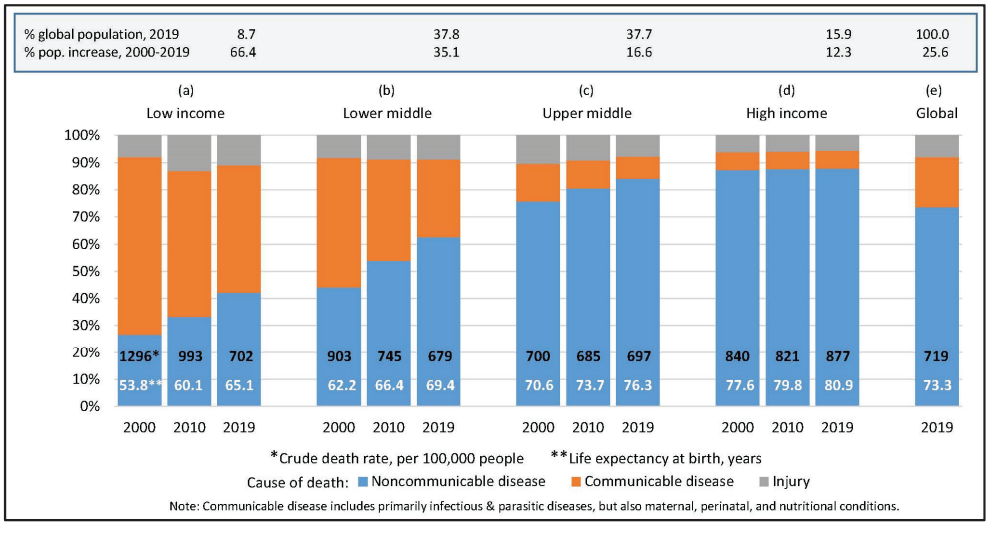

Figure 1. Trends in death rate, cause of death, and longevity at birth, by World Bank country income group, 2000–2019; All data available or calculated from data in the WHO's online GHO database. For longevity: https://www.who.int/data/gho/data/indicators/indicator-details/GHO/life-expectancy-at-birth-(years). For all else: https://www.who.int/data/gho/data/themes/mortality-and-global-health-estimates/ghe-leading-causes-of-death (both accessed on 5 December 2021).

Infectious diseases are still major killers in the poorest nations and new ones periodically flame into pandemics, but there will soon be fewer deaths from infectious disease than NCDs in low-income countries too (NCD Risk Factor Collaboration (NCD-RisC) 2017, p. 2639). NCDs are diseases of modernity and rising prosperity. They are increasing in all country income groups, and rates of NCD prevalence, morbidity, and mortality in developing nations are converging on those of the richest (GBD 2019 Risk Factors Collaborators 2020). As the epidemiological transition to NCDs becomes global, so do its challenges.

3. NCDs Are Harder for Governments to Prevent and Control Than Infectious Diseases

Communicable diseases are caused by biological agents not visible to the naked eye: bacteria, viruses, protozoa, fungi, and parasitic worms. They incubate unseen for days to weeks before symptoms appear and, upon arrival, tend to be acute and obvious (diarrhea, vomiting, chills, high fever, respiratory distress, skin lesions, swelling, pain, body rash). Throughout history such scourges decimated cities and armies with frightening speed. Public health and medical technologies dramatically reduced their ravages worldwide in little over a century by reducing involuntary exposure to the pathogens (e.g., safer water, sewer, and food security systems; vector control), reducing the susceptibility of individuals to infection if exposed to the pathogen (e.g., immunization), and improving survivability among infected individuals (antibiotics). These are primarily top-down interventions to stop community transmission of infectious agents.

These strategies do not work with NCDs. The disease process depicted in Table 1 shows why. They are not caused by involuntary exposure to biological agents, but mainly by voluntary self-exposure to known health-damaging products and lifestyles: using tobacco, eating an unhealthy diet, misusing alcohol, and being sedentary. These behaviors might seem innocuous in the short-run but, if habitual, they progressively damage multiple organ systems. Their population-attributable fractions, summed, show they were responsible for 35.2% of all global deaths in 2019.

Table 1. Percent (%) of global deaths in 2019 attributable to the 4 behavioral and 4 metabolic risk factors responsible for the global epidemic and burdens of NCDs.

Disease Process in Noncommunicable Diseases (NCDs)			
Behavioral risks * (% of deaths caused) →	Metabolic risks * (% of deaths caused) →	Top NCD causes of death ** (% of all global deaths) →	Health burdens
Tobacco use (15.4)	High systolic BP (19.1)	Coronary heart disease & stroke (27.8)	Comorbidities
Unhealthy diet (14.1)	High fasting BG (11.5)	COPD (5.8)	Hospitalizations
Alcohol misuse (4.3)	High BMI (8.9)	Tracheal, bronchus, lung cancer (3.6)	Years of disability
Sedentary (1.4)	High LDL cholesterol (7.8)	Diabetes (2.7)	Premature death

* GBD level 2 risks, ** GBD level 3 causes. BG = blood glucose; BMI = body mass index; BP = blood pressure; COPD = chronic obstructive pulmonary disease; LDL = low-density lipoprotein. Source: GBD 2019 Diseases and Injuries Collaborators 2020 (2020), with calculations on supplementary data at http://www.healthdata.org/results/gbd_summaries/2019 (accessed on 5 December 2021).

These health-damaging habits are easy to acquire but hard to break because they are evolutionarily novel perks of modernity and growing affluence. Like Trojan horses, we welcome their dangers into our lives as pleasures and conveniences. Alcohol and tobacco are physically addictive. The industrially manufactured ultra-processed food products that now dominate our diets (Wang et al. 2021) are seductive, if not addictive, because they are designed to override evolved satiety signals (Guyenet 2017). As the advertisement for a new potato chip in the 1980s boasted: "Betcha can't eat just one!" Other modern conveniences and enticements such as the automobile, television, video games, and social

media lure us into sitting for long hours. Indeed, schools require it, as seen in the high rates of physical inactivity—79–85%—among school-going youth in all four World Bank income groups (Guthold et al. 2020). The epidemiological transition to NCDs was wrought by this transition in health risks.

As it mounts, the internal damage these behaviors cause arouses no alarm because it produces no obvious symptoms. Health screenings can reveal the tell-tale signs of system damage—high blood pressure, blood glucose levels, BMI, and LDL cholesterol—but these conditions do not produce any outwardly noticeable symptoms of disease either. Together, this nexus of metabolic risk factors accounts for 47.3% of deaths worldwide.

A recent global study of 87 risk factors concluded that "there has been no real progress (since 1990) reducing exposure to behavioural risks, while metabolic risks are, on average, increasing every year (by 1.37%/year)" (GBD 2019 Risk Factors Collaborators 2020, pp. 1229, 1245). Of particular concern is the steep increase in obesity among children and adults, at least doubling in all four country income groups since 1980 and tripling in the high-income group (NCD Risk Factor Collaboration (NCD-RisC) 2017). Large prospective studies find that obesity can explain about 50% of diabetes type 2[1] cases (Feng et al. 2021), and diabetes is a risk factor for other NCDs, especially coronary heart disease and chronic kidney disease (Benjamin et al. 2019). The NCDs listed in Table 1 were responsible for 39.9% of all global deaths in 2019.

NCDs are easy to ignore even after diagnosis. Taking oral medications to lower high blood pressure, blood sugar, and cholesterol provides no discernible benefit day to day, nor does failing to take them seem to do harm. Many patients therefore fail to take them as prescribed (Benjamin 2012). And so it is with overeating and underactivity too. Even when the risk of complications later in life is acknowledged, they are too distant to seem urgent. Only the arrival of NCDs' predictable complications is unmistakable: heart attack, stroke, kidney failure, limb amputation, blindness, peripheral neuropathy, among others.

Table 2 points to a troubling trend noted in another global study (GBD 2019 Diseases and Injuries Collaborators 2020). That study used seven metrics to measure the global burden of disease 1990–2019: number of cases and age-standardized rates of prevalence, incidence, death, years lost to premature death (YLLs), years of healthy life lost to disability (YLDs), and disability-adjusted years of life (DALYs, the sum of YLLs and YLDs). The concern is that public health has focused primarily on life-saving interventions for NCDs, such as heart attack, stroke, and lung cancer, which have reduced their fatality. But there has been much less on interventions for less fatal but more disabling NCDs, such diabetes and COPD. The former three NCDs accounted for 78% of global deaths attributed to the leading five NCDs in 2019, but only 31% of all their cases and 31% of their healthy years lost that year to living with a disability (YLDs).

As populations continue to age, the prevalence of disabling NCDs keeps rising, but their burden in YLDs will increase disproportionately. This will severely tax healthcare systems worldwide. The effect of diabetes will be disproportionate, because it has by far the largest YLD rate, and its prevalence is rising fast in countries of all income levels (WHO https://www.who.int/health-topics/diabetes (accessed on 5 December 2021)). This is additionally concerning because public health campaigns have had limited success in preventing obesity, diabetes' biggest risk factor, or in gaining adherence to treatment among people diagnosed with diabetes (NCD Risk Factor Collaboration (NCD-RisC) 2016).

Table 2. Global burden of disease in 2019 by different metrics for the three broad categories of death (GBD level 1 causes) and the five NCDs with the highest death rates (GBD level 2 causes).

Disease Categories	Cases, 2019		Global Age-Adjusted Rate per 100,000 Persons, 2019					
	Most Ages	Millions	Prevalence	Incidence	Deaths	YLLs	YLDs	DALYs
Injuries	Teen-mid	1830	22,588	9259	55	2379	790	3169
Communicable diseases	Children	4540	58,287	346,347	141	8106	1377	9483
Noncommunicable diseases	Mid-late	7100	91,081	168,397	540	11,598	8607	20,205
Ischaemic (coronary) heart disease		197	2421	262	118	2177	67	2244
Stroke		101	1240	151	84	1550	218	1768
Chronic obstructive pulmonary disease		212	2638	201	43	681	245	926
Tracheal, bronchus, & lung cancer		3	39	27	25	545	7	552
Diabetes (both type 1 and type 2)		460	5555	268	20	416	443	859

YYL = years of life lost to premature death; YLD = years lived with a disability; DALY = disability-adjusted life years (YYL + YLD). Source: Supplemental 2-page summaries for GBD 2019 Diseases and Injuries Collaborators 2020 (2020) at https://www.thelancet.com/gbd/summaries (accessed on 5 December 2021).

4. International Surveys of Adult Functional Literacy Point to a Common Fundamental Cause of Nonadherence to NCD Treatments: The Cognitive Complexity of NCD Self-Management

Health literacy is "the degree to which individuals have the capacity to obtain, process, and understand basic health information needed to make appropriate health decisions" (https://www.hrsa.gov/about/organization/bureaus/ohe/health-literacy/index.html (accessed on 5 December 2021). The U.S. Surgeon General (Benjamin 2010) explained why it is critical: "As clinicians, what we say does not matter unless our patients are able to understand the information we give them well enough to use it to make good health-care decisions. Otherwise, we didn't reach them, and that is the same as if we didn't treat them." She also drew attention to 75% of Americans having trouble taking their medications as directed (Benjamin 2012). Seeking the cause, Marcum et al. (2013) identified specific sets of behaviors and barriers. All were cognitive: inability to perceive relevance, stay vigilant to what is relevant, weigh pros and cons, and imagine unobservable benefits; insufficient information processing capacity for the complexity of medication management; and inaccurate, irrational, or conflicting beliefs about medications. None of these cognitive skills are specific to medication. All are generalizable.

The international surveys of adult literacy listed in Figure 2 confirm that literacy is a capacity for processing information (Organisation for Economic Cooperation and Development (OECD) 2013, chp. 2). It is not just a collection of content-specific KSAs (knowledge, skills, and abilities), but the ability to acquire and use them effectively. They also reconfirmed what work-literacy researchers proved long ago (Sticht 1975). Literacy is not merely the ability to decode written words, but to understand what you read to successfully complete a given task. It is not reading to know, but to do; to accomplish the myriad tasks of daily life or on a job with what you read, hear, observe, learn, know, or can figure out—essentially, fluid intelligence. Not surprisingly, the separate scales on each literacy survey intercorrelate highly and line up along a single general factor (Kirsch et al. 2001, Tables 12-2 and 12-3), as do the various subtest scores on intelligence test batteries (Carroll 1993).

Figure 2 shows the population-level distribution of literacy proficiency scores grouped into 5 broad levels. In all four surveys about 50% of the population in these high-income countries is proficient at literacy levels 1 or 2, but no higher, and by age 80 virtually everyone functions at these lowest two levels.

Figure 3 lists sample items for each and graphs error rates for people of different proficiency levels performing tasks at different difficulty levels. People who peak at a given level have an 80% chance of correctly performing (20% of failing) tasks at that difficulty level. For instance, people who peak at a proficiency level 2 have a 20% chance of failing

level 2 items, such as finding two specified pieces of information in a short sports article. Their likelihood of failing level 1 items falls to 4% but they have, at best, a 50/50 chance on level 3 tasks. This includes the vast majority of individuals aged 70 and older (Figure 2, Panel d). Conversely, the minority of people who routinely function at proficiency levels 4 or 5 will make few errors on level 1–3 tasks and err at low rates on the more difficult level 4–5 tasks.

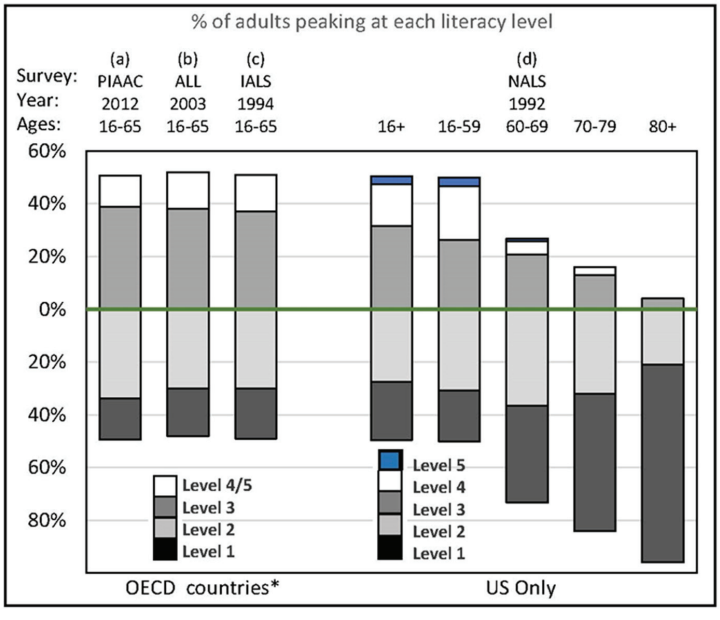

Figure 2. A nation's distribution of adult functional literacy (information-processing capacity) is predictable. * N of countries in the OECD surveys, respectively = 20, 6, 8 (U.S. included in the PIAAC and IALS). PIAAC = Programme for the International Assessment of Adult Competencies, ALL = Adult Literacy and Life Skills Survey, IALS = International Adult Literacy Survey, NALS = National Assessment of Adult Literacy, OECD = Organisation for Economic Cooperation and Development. Sources for PIACC (Organisation for Economic Cooperation and Development (OECD) 2013, Table A2.1); ALL (Organisation for Economic Cooperation and Development (OECD) 2011) and IALS (Organisation for Economic Cooperation and Development (OECD) 2000) data from online database at https://piaacdataexplorer.oecd.org/ide/idepiaac (accessed on 5 December 2021); and NALS (Kirsch et al. [1993] 2002, Figure 1.1 for ages 16+ and Brown et al. 1996, Tables 1.2 and 1.3, for specific age groups).

Especially important, the surveys' developers determined why the more difficult items (those failed more often) were more cognitively demanding. It was not content area (e.g., health, finances), format (prose, graphs, forms), or readability per se (Kirsch et al. 2001, chp. 13). It was the complexity of the information processing—mental manipulations—they required for people to answer correctly: more abstract concepts, more distant inferences, more plausible distractors, and more information to integrate.

To illustrate, the sample tasks at literacy level 2 require locating two specific pieces of information but the level 1 tasks only one piece. The items at level 3 require figuring out where to place a given piece of information in a two-variable matrix or calculating a result from two clearly specified variables in a chart. The level 4 items require finding a pattern along a timeline or the similarities and differences between two benefits plans based on descriptions of them, which requires independently recognizing which information is most relevant, then analyzing it to answer a specific question. The level 5 items require

the same independent recognition and analysis of relevant information, though in denser text, to draw a conclusion, but they also require evaluating that conclusion against a self-generated standard. Supplementary Table S1 uses a nutrition label to illustrate other specific contributors to task complexity.

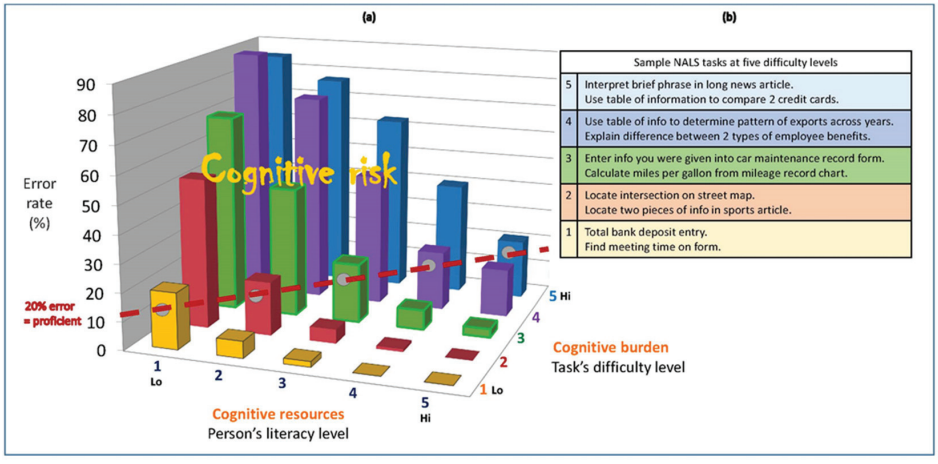

Figure 3. Sample literacy items and landscape of cognitive risk for individuals of lower literacy performing tasks of increasing difficulty. Sources for Panel (**a**), Kirsch et al. (2001, Exhibit 13–36 for document scale); for Panel (**b**), Kirsch et al. [1993] (Kirsch et al. [1993] 2002, Figure 1).

The 3-D landscape of probable error in Figure 3 shows how differences in people's abilities and tasks' difficulty levels predict population error rates like clockwork when work tasks are instrumental and performed independently without assistance. Lower ability and higher complexity both increase risk of error but error rates balloon when ability is low and task difficulty is high. Clinicians must keep cognitively vulnerable patients out of this territory because, like mental quicksand, it sucks them into nonadherence.

5. Diabetes Exemplifies How NCD Self-Management Regimens Invite Patient Error and Nonadherence

Poorly controlled diabetes elevates blood glucose (BG) levels. Persistently too-high BG causes blood cell clumping and increases blood viscosity, which impairs blood flow. Poorly controlled diabetes disrupts the metabolism of fats too, so adds excess lipids and cholesterol to circulate with the excess glucose. This toxic sludge slows healing and progressively damages organ systems body-wide, eventuating in one or more of diabetes' complications, such as limb amputation and retinopathy. Diabetes is the leading cause of cardiovascular disease, end-stage kidney disease, and, among 18–64-year-olds, new cases of blindness in the U.S., virtually all preventable (Centers for Disease Control and Prevention (CDC) 2020, pp. 11–12). It now accounts for one in four healthcare dollars in the U.S. (American Diabetes Association (ADA) 2018), partly due to high rates of preventable emergency department (ED) use and hospitalization for dangerous BG levels (Geller et al. 2014).

Diabetes is an especially taxing NCD to self-manage, as the job description in Table 3 suggests. Patients must take hands-on control of a metabolism no longer on auto-pilot to keep BG levels within a target range, neither too high nor (if using insulin) too low. This requires simultaneously coordinating three inputs that affect BG level (medication, carbohydrate, physical activity) and factoring in other circumstances as well (current BG, illness) to keep pre- and post-meal BG levels moving within the target range.

Table 3. The higher-order cognitive processing required for optimal diabetes self-management (DSM). (From "Safe-Guarding Cognitive Access to Diabetes Self-Management as Abilities Decline with Age" by Gottfredson and Stroh 2021, pp. 9–11. Copyright 2021 by Canadian Diabetes Association).

Job of DSM
Purpose:
• Keep diabetes under daily control in the often changing and unpredictable circumstances of everyday life.
Goals:
• Near term: Keep blood glucose (BG) within normal limits. • Long term: Avoid complications and maintain quality of life.
Major duties:
• Coordinate activities that influence BG (food, medication, physical activity). • Anticipate effects on BG of those activities and their relative timing. • Recognize symptoms indicating that BG is too low or too high. • Adjust food, medicine, physical activity (as needed) to maintain or regain optimal BG. • Obtain BG data from glucose meter or continuous glucose monitor to determine if BG is trending to hypo- or hyperglycemia. • Determine timing and type of corrective action when BG levels are too low (glucose tablets, glucagon, emergency medical care). • Detect and seek treatment for complications of elevated BG levels (vision changes, neuropathies, foot ulcers). • Plan ahead for the unexpected and unpredictable (delayed meals, delayed or missed medication). • Adjust DSM for other influences on BG (infection, emotional stress, insufficient or poor-quality sleep). • Coordinate DSM with other self-care regimens (comorbidities, polypharmacy). • Manage conflicting demands on time and behavior (DSM, family, work). • Update DSM skills and knowledge, as needed (changes in technology, medication, impairments, comorbidities).

Diet is important in all NCDs but especially tricky in diabetes because patients must calibrate carbohydrate intake. Nutrition labels are helpful, but even their simplest uses require considerable information processing. A task analysis of one such use in Supplementary Table S1 illustrates how many inconspicuous elements of a task can raise its complexity. The sample items in Figure 3 suggest that even simple-seeming uses of nutrition labels are more cognitively demanding than level 1 or 2 literacy tasks.

Other diabetes self-management (DSM) tasks are yet more cognitively demanding. For instance, providers often ask people who are newly diagnosed or having difficulty controlling their BG levels to record their BG readings, medication, and perhaps carbohydrate intake by meal or time of day in a multi-row, multi-column chart. This is at least a literacy level 3 task. They also advise patients to look for patterns in their BG readings relative to food, medication, and physical activity and to adjust one or more of them, as necessary, to improve BG control. Such analyses and judgments—do-it-yourself research—are clearly level 5 difficulty.

Moreover, DSM is not a series of disconnected tasks, as are literacy surveys. It is a job, though one with no days off and scant training: a constellation of tasks that must be prioritized and coordinated to meet a specified goal. The job description in Table 3 leaves no doubt that DSM sits atop the peak of the error landscape in Figure 3. Good judgment is especially critical when self-administering insulin, because using the wrong type or amount, failing to eat enough carbohydrate or soon enough after administration, and other miscalculations and misadventures can land one in the ED (Geller et al. 2014). In the U.S., insulin is second only to the blood thinner Warfarin in ED visits for adverse drug events (Shebab et al. 2016). As of 2018, 32.2% of all adults with diagnosed diabetes in the U.S. were prescribed insulin to manage their BG, not just the 5% with type 1 who must use it to survive (CDC, https://gis.cdc.gov/grasp/diabetes/DiabetesAtlas.html (accessed on 5 December 2021)).

DSM becomes even more complicated and error prone when, as is typically the case, information is incomplete and conditions are ambiguous, changing, uncertain, unpredictable, or stressful. Effective BG control is never certain for even the most conscientious and capable adherents to DSM regimens. Anything that affects metabolism can disrupt con-

trol, often making out-of-range BG levels difficult to anticipate, explain, and prevent. The emotional and cognitive burden can skyrocket when family and work schedules change, mealtimes are irregular, carbohydrate content of meals is unknown or highly variable, and life's ups and downs divert time and attention (for examples, see Seitles 2021a, 2021b, 2021c, 2021d; Seitles 2021). Not only do delayed meals, unanticipated surfeits or deficits of carbohydrate, night shifts, and stress affect metabolism directly, but their sometimes unpredictable effects on BG demand more analysis by patients (why did that happen?) and decision making (what do I do now?).

By any measure, DSM is a complex job, as complex as many mid-level occupations (Gottfredson 1997). It is also a fast growing one. Diabetes cases quadrupled worldwide in the last four decades, reaching a global prevalence of 8.5% among adults by 2014 (https://www.who.int/news-room/fact-sheets/detail/diabetes (accessed on 5 December 2021)).

6. New Hope: The Medical Professions Could Adapt Existing Person-Job Match Tools and Techniques to Help Clinicians Increase the Cognitive Accessibility of NCD Self-Management

Our best hope for meeting individual patients' needs while controlling the crushing costs of nonadherence may lie with improving patients' cognitive access to NCD-SM. Scott Adam's "amazingly smart deviants" could help by developing the tools listed in Table 4 and redesigning electronic medical records systems to both enable and incentivize their use. The medical profession would also benefit from healthcare quality metrics and decision trees for individualizing self-care regimens to accommodate differences in cognitive capacity, just as there are for selecting appropriate medical treatments for patients with different medical profiles.

Medical and health associations regularly update their evidence-based standards of care and practice guidelines on patient care. All urge clinicians to consider many patient attributes, but rarely do they mention cognitive capacity. They always urge taking health literacy into account, but are vague about whether it is a general capacity for processing information or a teachable set of specific KSAs. They also urge screening older individuals for dementia, as appropriate, but otherwise imply that cognitive capacity is dichotomous—normal or abnormal. Care standards have begun to identify regimen complexity as a barrier to adherence for older adults, but seldom mention it otherwise.

Fortunately, experts in job analysis, personnel selection, job performance, psychometrics, and allied fields have developed tools and techniques for other cultural institutions that must take in, assess, place, and train individuals whose wide differences in cognitive capacity affect how quickly and well they learn a curriculum or job: government-supported schools, large corporations and government agencies, and the military services. All must attempt person-job match, especially cognitive match, to optimize individual-level and/or institutional-level performance. Many of these experts belong to the American Psychological Association's Division 14 (Industrial and Organizational Psychology).

Health organizations, agencies, and insurers could engage these experts to adapt existing tools and techniques to reduce patient nonadherence. Table 4 (Part A) lists ones that would assist healthcare providers. Part B offers strategies for how clinicians might use them. These tools can optimize patient mastery and outcomes of NCD-SM, but few healthcare providers have the wherewithal to develop them on their own.

Table 4. Strategies to help clinicians reduce a patient's cognitive barriers to NCD self-management.

Recommendations for increasing the cognitive accessibility of NCD self-management regimens	
A. Medical/health associations & researchers develop new training, tools, & techniques for clinicians	
Persons: cognitive capacity & false beliefs	
A.1	Add cognitive-access-to-care modules to medical and public health training programs. They would explain the wide variation in people's cognitive needs and how to meet them. Physical, financial, and cultural access to NCD care mean little without cognitive access to it.
A.2	List the common misunderstandings and false beliefs that patients bring into care. Diabetes Disasters Averted (http://www.diabetesincontrol.com/resources/disasters-averted (accessed on 5 December 2021)) proves that nothing should be assumed too simple or obvious to need explaining.
Jobs: cognitive complexity	
A.3	Write job descriptions for all NCDs. Use both clinicians and patients or their caregivers as subject matter experts. The later will help care teams better conceptualize what patients have to manage and coordinate in real-world settings. See Seitles (2021) and Seitles (2021a, 2021b, 2021c, 2021d) for compelling audio and written accounts by parents of type 1 children.
A.4	Expunge needless complexity from written materials for patients (e.g., no jargon, no long contorted sentences, clear organization, informative headings). See the U.S. Centers for Disease Control's Plain Language guides (Centers for Disease Control and Prevention (CDC) 2019). They help whittle complexity down to what is inherent.
A.5	Audit the cognitive demands inherent in effective NCD self-management. Engage job analysts to identify the information-processing requirements in typical regimens, including their configuration of tasks.
A.6	Perform task analyses of the most critical tasks in self-managing a particular NCD and where patients are most vulnerable to error. See Kirsch et al. (2001) for research on what adds to a task's complexity.
A.7	Compile a list of common errors in self-management so that practitioners can anticipate and preempt them. Search the literature and survey practitioners.
A.8	Compile a list of the most dangerous patient errors in NCD-SM. For diabetes, see studies of preventable ED visits and hospitalizations for hypo- or hyperglycemia (Geller et al. 2014). They reveal the sorts of seemingly obvious facts that patients may need to be explicitly (re)taught.
A.9	Identify self-care tasks that the average person is not likely to perform correctly unless they get extra instruction. Use the landscape of error in Figure 3.
B. Clinicians iteratively adjust self-care regimen and training to fit a patient's cognitive needs	
Person: cognitive needs, barriers, and resources	
B.1	Screen for dementia, if suspected. There are no short, unobtrusive tests of cognitive capacity in the normal range (from the 2nd to 98th percentile), nor is one needed. The patient's performance on the criterion–self-management—is the best guide to next steps in adjusting their NCD-SM tasks and training. See B.7-15 below.
B.2	Determine whether the patient has functional impairments (e.g., sight, hearing, touch, swallowing) or comorbidities. All make NCD-SM more difficult and error-prone, the latter by multiplying the NCD-SM tasks, medications, and doctors a patient must coordinate.
B.3	Elicit the patient's questions, concerns, and beliefs about their NCD and NCD-SM. False beliefs must be preemptively corrected lest they impede NCD-SM. Patient questions and concerns indicate not just the patient's particular needs and preferences for regimen content, but also their knowledge and intellectual skills for implementing the regimen.
B.4	Be aware, however, that patient reporting is also a cognitive exercise. For instance, the patient may not know what is relevant. Older adults are especially reluctant to reveal declining mental capacity, but see Gottfredson (2019) for interview questions to elicit their cognitive needs and capacities.
B.5	Identify sources of cognitive support and interference in NCD-SM. Informal sources of information or support can be badly mistaken (e.g., friends offering leftover insulin). Knowledgeable family members can be valuable partners in NCD-SM.
B.6	Identify situational disruptions to self-management. Keeping external circumstances under better control can help patients keep blood glucose under better control. Routine is an underappreciated tool for the diabetes toolkit that many patients carry everywhere.
Person-job cognitive fit: the regimen	
B.7	Estimate a conservative starting point for a regimen's complexity. For this, use any tools available from Section A above, patient attributes in B.1-6, and the landscape of error in Figure 3. Complexity can be increased over time once patients experience some success. Nothing builds self-confidence and motivation as well as developing actual competence.
B.8	Monitor patient difficulties and errors at successive levels of task difficulty. Locating their errors in the matrix of error probabilities (Figure 3) reveals where cognitive demands must be lightened to avoid pushing the individual into cognitive overload.

Table 4. *Cont.*

Recommendations for increasing the cognitive accessibility of NCD self-management regimens	
Person-job cognitive fit: the regimen	
B.9	Administer a diabetes distress scale or equivalent to identify possible sources of cognitive overload. Remediate overload before assuming that a patient needs treatment for its natural sequelae: depression, anxiety, and loss of motivation.
B.10	Simplify regimens when necessary to bring them back within the individual's cognitive reach. No matter how few self-care tasks a patient eventually masters, each one mastered does far more good than them giving up altogether.
B.11	Enlist cognitive assistance from capable caregivers or qualified health care providers if the individual cannot safely self-manage their NCD.
Person-job cognitive fit: the training for it	
B.12	Sequence instruction for efficient learning. Teaching tasks in order of their information processing complexity eliminates the needless cognitive hurdles that poorly organized instruction so often imposes on learners. The classic tool for this in school settings is Bloom's taxonomy of cognitive educational objectives, from least to most cognitively complex (Anderson and Krathwohl 2001). Supplementary Table S2 lists typical components of DSM ordered by Bloom level. This tool doesn't eliminate the inherent information processing demands it helps to reveal, but helps ensure that individuals grasp a task's prerequisites before attempting it.
B.13	Adjust learning demands up or down in complexity to identify the individual's "desirable difficulty range" for learning (Lee and Anderson 2013). This is like computer adaptive testing, where the first items administered are of middling difficulty but subsequent items increase or decrease in difficulty depending on the individual's errors on prior items.
B.14	Adjust the pace, depth, breadth, and abstractness of material taught to fit the individual's ability to take it in. Low ability learners benefit most from highly structured, detailed, concrete, contextualized, hands-on, theory-free, step-by-step instruction of task-specific skills. High ability learners benefit most from the opposite: abstract, theoretical, self-directed, and incomplete instruction that frees them to organize new and old information in novel ways (Laurence and Ramsberger 1991). Slower instruction necessarily means covering less content.
B.15	Triage instructional content as necessary. Winnow SM tasks first by how critical each is to the patient's well-being but exclude those too hazardous for that patient to attempt.

7. Additional Hope: Public Health Researchers Could Estimate the Global Disease Burden Attributable to Cognitive Factors and Identify WHO "Best Buys" for Reducing It

Epidemiologists have already done monumental work identifying trends in risk factors and best buy interventions for improving global health. Hundreds, if not thousands, have banded together in consortia, such as the NCD Risk Factor Collaboration (NCD-RisC) and the Global Burdens of Disease (GBD) Study, to scour the world for evidence and model it to identify successes, troubling trends, and ways to meet unmet needs. They could accelerate their contributions by adding two health risks to their roster: cognitive capacity of persons and complexity of task environments.

Population exposure to cognitive risk (the horizontal axis in Figure 3) can be estimated with publicly available data from professionally developed international assessments of adult literacy (Figure 2) and school learning (e.g., PIRLS, Progress in International Reading Literacy Study, https://www.iea.nl (accessed on 5 December 2021), and TIMSS, Trends in International Mathematics and Science Study, https://www.iea.nl (accessed on 5 December 2021)). These results can also help identify global or national pockets of elevated cognitive risk. The importance of exposure to a health risk is estimated with risk-outcome pairs (how big an impact particular risks have on particular outcomes). The literatures on health literacy, intelligence, and cognitive epidemiology (Deary 2021) are replete with risk-outcome pairs linking cognitive capacity and health outcomes at every stage of the NCD disease process in Table 1.

Population-level exposure to cognitive risk changes little over time and generations, so it is effectively a fixed constraint on person-job matching in a population.[2] But the other half of the match is not, as detailed in Table 4. Much like air pollution, the cognitive complexities in NCD prevention and self-management (the complexity axis in Figure 3) are modifiable environmental risks. Risk-outcome pairs (akin to the error probabilities in Figure 3's vertical axis) are often used to identify the biggest drivers of the rising global burden of NCDs as well as opportunities for slowing or reversing it. Charting the landscape

of cognitive-attributable errors and nonadherence to treatment can, in like manner, point to populations, places, and practices in NCD treatment where cognitive accessibility needs improving. Epidemiologists could, for example, estimate how the global burden of LYDs might change if interventions decreased certain types of nonadherence, especially among individuals and families with high exposure to elevated cognitive risk. Only with such information can we avert the "slow-motion disaster" that NCDs portend.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/jintelligence9040061/s1, Table S1: Sample task analysis of label use that illustrates how to uncover a task's nonobvious demands for information processing; Table S2: Example of instructor using Bloom's taxonomy of educational objectives (cognitive domain) to sequence instruction by complexity of information processing.

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Notes

[1] Diabetes type 2, but not type 1, is a lifestyle disease attributable to unhealthy behaviors. Type 1 (about 5% of diabetes cases) is an autoimmune disorder of as-yet unclear origins in which the pancreas ceases to produce enough insulin for the individual to survive. In type 2, the body's cells begin resisting insulin's action to deliver glucose to them, setting off a cascade of physiological dysregulation. After onset, however, their progression and complications are much the same.

[2] Years of education would be a misleading substitute for a population's distribution of cognitive risk, especially in countries without universal secondary education. Education is an indicator of a nation's socioeconomic development, not its cognitive development. Education levels grew dramatically in developed nations during the last century from basically the same cognitive substrate. Moreover, while cognitive capacity is a useful predictor of on-the-job performance, years of education attained is not. There is convincing evidence for a mechanistic relation between cognitive ability and job performance, but not for education and job performance. Education level seems to be mostly a confounder in correlations between ability and real-world performances.

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Review

The Fight against Infectious Diseases: The Essential Role of Higher-Order Thinking and Problem-Solving

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Abstract: The development of a vaccine marks a breakthrough in the fight against infectious diseases. However, to eradicate highly infectious diseases globally, the immunization of large parts of the population is needed. Otherwise, diseases, such as polio, measles, or more recently COVID-19, will repeatedly flare-up, with devastating effects on individuals and, in the worst case, on significant shares of the world population. For example, polio has been almost eradicated over the past three decades through an unprecedented global effort, but complete immunization has not yet been achieved. In this article, we use polio as an example to show how the global effort of developing and administering a vaccine can be understood as solving a complex problem since it involves cultural, political, and geographical barriers that demand solutions in dynamically changing and highly versatile environments. Referring to the literature on problem-solving, higher-order thinking, and complex reasoning, we demonstrate how the ability to deal with real-world environments that are complex and dynamically changing, adapting initial solutions to new circumstances and collaborate efficiently with others, has been essential for this endeavor. We argue that problem-solving abilities form one basis for solving consequential world problems.

Keywords: problem-solving; higher-order thinking; real-world environments; infectious diseases

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1. Introduction

This Special Issue addresses the question of "How Intelligence Can Be a Solution to Consequential World Problems". A multitude of consequential world problems are facing humanity today—problems that are not just important but affect all people living on our planet. Climate change and the COVID-19 pandemic are just two examples that quickly come to mind. What consequential world problems have in common is that there exists no single, simple solution to solve them. Consequently, problem-solving skills are required to solve them, which are often subsumed under the umbrella term *intelligence*. Broad definitions of intelligence include adapting to the environment in novel situations to overcome obstacles (e.g., Neisser et al. 1996) attributing to intelligence an integral role in tackling consequential world problems. In fact, intelligence research has a long history, and intelligence is seen as one of the most important ingredients for life success (e.g., Gottfredson 2002; Roth et al. 2015). However, there are also concerns that essential skills for solving problems in our current society are not fully reflected in narrow definitions of intelligence and, thus, are not part of the standardized intelligence tests (Halpern and Dunn 2021; Stanovich 2009; and Stanovich 2014). For instance, although problem-solving skills and intelligence are both theoretically and empirically related (e.g., Greiff et al. 2014 and Stadler et al. 2015), there are certain problem-solving skills, which are essential for solving consequential world problems but not reflected in traditional intelligence tests (for instance, detecting and controlling autonomous changes in problems; see Stadler et al. 2019). In the current article, we review the role of higher-order thinking (HOT) skills as one

promising candidate reflecting integral, established problem-solving skills. As one example from the set of consequential world problems, we focus on the approach to eradicate the poliovirus. The main message of this article is not that intelligence is irrelevant for solving consequential world problems, but that for solving these problems integral problem-solving skills, such as HOT, need to be considered on a more fine-grained level, which might inspire both (1) policymakers to continue the efforts for implementing and adapting these skills in school curricula, and (2) researchers to further consider these skills in narrow descriptions of intelligence and its assessments.

2. Higher-Order Thinking and Problem-Solving

Higher-order thinking refers to the skills that go beyond memorizing and recalling information, but instead emphasize the reasoned application of knowledge in a diverse set of contexts (Brookhart 2010, and Greiff and Martin 2015). Individuals with strong HOT skills can analyze and evaluate complex and possibly new information; categorize, manipulate and combine facts; search for (innovative) solutions; understand concepts; transfer and connect knowledge; draw upon a broad perspective to solve problems; and generate ideas and develop insightful reasoning (Anderson et al. 2001). HOT skills are often described in educational contexts as belonging to the three highest levels in Bloom's taxonomy, i.e., analyzing, evaluating, and creating, and are seen as indispensable for 21st-century learning.

HOT typically becomes relevant in unfamiliar situations, when we are confronted with a given state that we want to transform into a goal state, but the steps and actions required to do so are unknown (Greiff and Martin 2015). A situation in which our previous experiences and routine solutions are not applicable or not sufficient to reach a goal state is defined in cognitive psychology as a *problem*. Thus, to reach the desired goal state, we need to engage in the process of problem-solving. Problem-solving refers to any kind of goal-directed sequence of cognitive operations (Anderson 1982) by which an individual moves from an initial situation, in which the problem is identified and represented, to a desired goal state by manipulating the components of the problem to reach a conclusion or to solve the problem (Jonassen 2000; Osman 2017; and VandenBos 2007). On a generic level, problem-solving includes the process of constructing a mental model (i.e., a mental representation) of the problem, the search for solutions, and the implementation and monitoring of the solutions (Gick 1986). Thus, any problem-solving process requires a certain amount of complex thinking, and therefore involves HOT, making the two closely related (Greiff and Martin 2015).

Since problem-solving is a situationally specific activity, the demands of the problem situation are not uniform and often require non-routine solutions. In other words, problems are not equivalent in content, form, or process (Jonassen 2000) and thus require a set of problem-solving skills all involving HOT, each with a specific focus, to reach a solution. We argue below those three problem-solving skills, namely complex, adaptive, and collaborative problem-solving, are key competencies when dealing with consequential world problems. Before making this argument, we must first take a closer look at the characteristics of consequential world problems.

3. Consequential World Problems and How They Relate to Problem-Solving Skills

The United Nations lists no fewer than 22 issues that it considers to be most urgent at present, e.g., aging, atomic energy, climate change, poverty eradication, health, migration, or water (United Nations 2021). Common to these problems is that they tend to be ill-structured (i.e., with no clear path to a solution, no single correct solution, and various possible points for intervention), dynamically changing, ambiguous, and intransparent (i.e., not all the information is given from the beginning and data are often missing or invalid). In addition, there are often many parties involved with competing interests and needs, not all of which can be satisfied, and they are often closely tied to other issues[1] (see the Nautilus Institute for Security and Sustainability 2008; Sternberg et al. 2019). Considering

these characteristics, it becomes clear that it indeed takes more than an IQ and declarative knowledge to tackle these types of problems, bringing us back to the question of particularly relevant problem-solving skills.

First, when problems are not static but unfamiliar and dynamically changing, such as the global problems described above, complex problem-solving (CPS; e.g., Greiff et al. 2013) comes into play in finding a solution. CPS describes skills in successfully coping with new and rapidly changing problem situations in which no routine solution is available (Mayer and Wittrock 2006). The main characteristics of complex problems are that not all of the information is given at the beginning (intransparency), that there are multiple input variables affecting the output variables (complexity), and that some output variables change autonomously, without user input (dynamics; Greiff et al. 2013). To solve a complex problem, the problem solver must first acquire knowledge by actively exploring the problem and then apply this acquired knowledge to achieve specific goals (Funke 2001; Wüstenberg et al. 2012).

Closely related but not equivalent to CPS is adaptive problem-solving (APS; Greiff et al. 2017). APS reflects the ability "to react to unforeseen changes and new information in a flexible and adaptive way" (Greiff et al. 2021), which is certainly of great value when it comes to consequential world problems. Since APS involves the ability to achieve one's goals in a dynamic situation, in which a solution procedure is not immediately available, it directly meets the requirements of the described characteristics of global problems. More concretely, consequential world problems require the problem-solver to consider the various resources in different information environments (be they physical, social, or digital) in addition to their own mental activities, because the former often change dynamically during problem-solving. These changes occur because consequential world problems typically consist of a set of complex, interacting issues that evolve in a dynamic social, political, and cultural context. New problems often emerge as an unintended result of the problem-solver's actions and attempts to understand the problem. Consequently, the constant monitoring of the problem situation is needed, as well as an adaptation as necessary. Hence, adaptive problem-solvers must engage not only in cognitive, but also strongly in metacognitive processes to define the problem, search for information, and apply a solution (Greiff et al. 2017). Metacognitive processes describe the ability to adjust one's comprehension of the problem as necessary, evaluate the possible solutions, and monitor the progress toward set goals (Greiff et al. 2021).

This process of adaptation and reflection also requires rational thinking. This means that the problem solver needs to reflect whether the solution can be achieved by efficient means (instrumental rationality) and whether the beliefs of the problem solver correspond to real-world evidence (epistemic rationality; Stanovich 2014 and Stanovich 2016).

In addition, addressing the consequential world problems always involves different groups of people, whether in collaborating on a solution and benefitting from each other's knowledge or negotiating compromises between groups with different interests. This is where collaborative problem-solving (ColPS; Graesser et al. 2018) skills are of great value. ColPS has been defined in different ways (see Han et al. 2021), but one common definition describes ColPS as "the capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills, and efforts to reach that solution" (Organization for Economic Co-operation and Development; OECD 2017). In a sense, ColPS reflects the application of individual problem-solving skills in a group context (Greiff 2012). ColPS skills are relevant in the contexts in which we interact with others, whether at school, at work, or in our personal lives (Graesser et al. 2018; OECD 2017; and Stadler et al. 2020).

As we have seen, consequential world problems have specific characteristics that require specific skills among problem-solver(s) to be addressed appropriately. We argued that among the many different problem-solving skills, three might be of particular value, namely complex, adaptive, and collaborative problem-solving skills. It is important to

emphasize that we do not claim that these are the only relevant skills; however, we do believe that they, together with the associated HOT skills, can guide the process of reaching the desired goal state, i.e., the (partial) solution to a consequential world problem. Moreover, these skills do not function independently, but rather are interlinked and applied in close conjunction with each other. We will now apply what we have derived theoretically to the concrete example of infectious diseases to demonstrate how HOT and problem-solving skills come into play.

4. The Global Fight against Polio: An Example of Successful Problem-Solving in Action

Poliomyelitis (polio) is a highly infectious viral disease transmitted mainly via the fecal–oral route. The virus replicates in the intestine, from where it can enter the nervous system and can cause paralysis (World Health Organization; WHO 2021). Polio predominantly affects children under five years of age. Even before the COVID-19 pandemic, infectious diseases, such as polio, were one of the most critical issues facing humanity. They affect the entire world and pose a constant health and economic threat. Thus, infectious diseases are a consequential world problem that exhibits the typical characteristics of being ill-structured, dynamically changing, intransparent and complex, ambiguous, and solvable only through internationally coordinated and interdisciplinary approaches (Becker et al. 2006). An example of such an approach is the Global Polio Eradication Initiative (GPEI).[2] The GPEI is one of the largest global health initiatives of all time (Cochi et al. 2014) and has set the goal of eradicating polio worldwide. When GPEI was launched in 1988, wild poliovirus had spread to more than 125 countries and was paralyzing about 1000 children per day (Bill & Melinda Gates Foundation 2021). Over the past three decades, the number of cases declined by more than 99%, thanks to extensive vaccination efforts. As of today, Pakistan and Afghanistan are the only countries in which wild polio occurs (Bill & Melinda Gates Foundation 2021). When examining the efforts of eradicating the poliovirus more closely, it becomes evident that there were many obstacles, uncertainties, and overlapping issues along the way (not yet completed), and that HOT and related problem-solving skills were involved in each step of the process.

The starting situation thus met all the main criteria of a complex problem as introduced above. That is, the situation was intransparent and complex, and no uniform approach had yet been established in the countries concerned. In detail, in many countries, there was a lack of information among both the population and governments, and there were multiple, variable, and often uncontrollable factors at play that influenced the achievement of the major goal of eradicating polio worldwide. In fact, the (causal) relationships between multiple interrelated variables, such as the acceptance of the vaccination campaign, religious beliefs, current political situations, or logistics, had to be uncovered and (rational) actions needed to be planned and executed based on these insights. One example of multiple variables being involved is that insecurity in certain regions led to logistic obstacles potentially impacting the vaccine quality (e.g., Ahmad et al. 2020).

Indeed, the initial solution process was akin to solving a complex problem: The GPEI first acquired knowledge about the social, cultural, political, and religious barriers that may exist in a country and that need to be understood to improve vaccination coverage. This knowledge was then applied to find ways to work with local political leaders and health professionals (Bill & Melinda Gates Foundation 2021 and Cochi et al. 2014). The strategy developed to address the problem involved training and mobilizing millions of volunteers and health workers. It was also recognized as critical to reaching households not reached by other health initiatives to completely eradicate polio.

Despite the great initial success with this strategy even in developing countries, polio outbreaks continued to emerge in certain areas, such as parts of Africa or Pakistan. In other words, the situation frequently changed dynamically during the problem-solving process. For instance, the migration of unvaccinated people to regions with an already successful vaccination campaign in Pakistan led to a stronger transmission of the poliovirus, again,

in these regions. These migrations were not caused by the GPEI (hence not caused by the "problem solver") but by political conflicts or military operations (Ahmad et al. 2015, and Basharat and Shaikh 2017) and thus can be considered as a dynamic factor.

Hence, constantly monitoring the situation with cognitive and metacognitive capacities was (and still is) strongly needed to remain on target along the journey to achieving the goal of eradicating polio globally. This adaptive problem-solving process involved, for example, searching for new information to figure out why these outbreaks kept flaring up despite the vaccination efforts and successes. These needed to be analyzed and evaluated to generate ideas and develop insightful, rational solutions. For instance, high population mobility and incomplete, outdated, and sometimes only hand-drawn maps of the affected regions were identified as decisive factors, as these maps led to the exclusion of entire settlements preventing a high vaccination rate in these regions (e.g., Barau et al. 2014). As a result of this insight, mapping and planning tools were applied and a robust global surveillance and response system was established. These coordinated immunization systems, including knowledge about the demographic structure of the population and its social, political, and religious background, have also served as a platform for other important health interventions and have been used to respond to other public health threats, such as COVID-19 and Ebola (Bill & Melinda Gates Foundation 2021).

Finally, the description of the problem space and the many social, political, and religious obstacles (Bill & Melinda Gates Foundation 2021) encountered during the problem-solving process should have already made it clear that ColPS skills were required at every step of the process. This seems intuitive, given the global collaboration among the different organizations and individuals involved in the GPEI, each with different areas of expertise and background knowledge. Similarly, communicating with local political and religious leaders as well as the volunteers requires the ability to engage in a process in which an attempt is made to solve a problem collaboratively.

5. Conclusions

The example of the GPEI clearly shows the many challenges in today's world and the associated skills needed to address them. It also demonstrates the importance of problem-solving skills, as well as the importance of HOT skills associated with the problem-solving process (e.g., synthesizing, analyzing, reasoning, comprehending, applying, and evaluating information) for reaching a sustainable solution to consequential world problems. The success of the strategy, when fully implemented, was demonstrated by India's success in stopping polio in January 2011, in one of the most technically difficult places to do so (WHO 2021). Through the efforts to eradicate polio globally, the GPEI paved the way to overcoming logistic, geographic, social, political, cultural, ethnic, gender, financial, and other barriers to working in the poorest and least accessible areas (Bill & Melinda Gates Foundation 2021). Moreover, the GPEI did more than advance the fight against polio. It created new ways to improve human health in developing countries through political commitment, funding, planning and management tools, and research (Bill & Melinda Gates Foundation 2021). In an extension of this process, which can also be described as a comprehensive problem-solving process, the knowledge and resources generated as part of the GPEI are now being transferred to address other global health threats, such as the COVID-19 pandemic. Hence, although the GPEI has not yet reached its final goal, it can serve as a successful example of why problem-solving and HOT skills are, in our opinion, one indispensable factor for such endeavors, although it goes without saying that these are not the only relevant skills or the universal solution to consequential world problems.

We want to stress, again, that HOT skills must be applied in a rational way when solving consequential world problems. That is, efficient ways of solving problems need to be considered and it needs to be evaluated whether solving strategies and beliefs are in line with the current evidence.

We would also like to emphasize an important implication that arises from the demonstrated relevance of HOT and problem-solving skills for addressing consequential world problems, namely the need to systematically integrate these skills into school curricula. We believe that schools need to go beyond preparing students to perform well on standardized tests, but rather prepare them to better meet the demands of a rapidly changing society characterized by accelerating globalization, the emergence of new digital technologies, and the rise of ever more challenging consequential world problems. Given the growing need for skills, such as collaboration, critical thinking, problem-solving, and the ability to acquire new skills and information (typically referred to as 21st-century skills; Ananiadou and Claro 2009 and the National Research Council 2012), it is not surprising that educational researchers and many contemporary educational curricula and assessment frameworks, such as the Programme for International Student Assessment (OECD 2004, 2013), call for coordinated efforts to integrate these skills into the curricula and better educate students in them. This is further underscored by the inclusion of problem-solving in PISA and the Programme for International Assessment of Adult Competencies (PIAAC; OECD 2012).

In conclusion, we believe that HOT and problem-solving skills form an essential cornerstone for addressing consequential world problems, and that systematically integrating these skills into school curricula will go a long way toward addressing global problems.

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Notes

1 Please note that this list should not be considered exhaustive.

2 The GPEI is a public-private partnership led by national governments with six partners: the World Health Organization; Rotary International; the US Centers for Disease Control and Prevention (CDC); the United Nations Children's Fund (UNICEF); the Bill & Melinda Gates Foundation; and Gavi, the vaccine alliance.

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