Rainer M. Holm-Hadulla
Joachim Funke
Michael Wink *Editors*

Intelligence – Theories and Applications

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Preface

“Intelligence: Theories and Applications” focuses on a characteristic that we find in living beings of all kinds: the capacity to adapt to different environments. Intelligence has made humans a successful species over thousands of years. But will it stay that way? Ecological problems, wars and pandemics threaten humankind. Artificial intelligence (AI) now seems to be superior to human intelligence in some respects. Are humans in danger of being ousted by AI? These topics call for a multi- and interdisciplinary approach.

This multi- and interdisciplinary view derives in the present volume from the wide range of perspectives represented by a comprehensive university. Authors from the natural sciences and medicine, the humanities, and cultural studies discuss their understanding of intelligence from different perspectives and based on different research methods. In addition, there are external contributions that underline the social relevance of the phenomenon. These contributions address very different aspects of the general topic and thus ultimately achieve an interesting diversity of aspects. In their introductory chapter, Rainer M. Holm-Hadulla and Hannes Wendler take on the task of summarizing and classifying a variety of different perspectives on intelligence and advance an integrative model of its concept Back in 2000, one of the authors already curated an exciting yearbook on the topic of “Creativity” (Holm-Hadulla, 2000).

The contributions to this volume of the *Heidelberg Yearbook*, which has existed since 1805, are presented here in keyword form:

In their introductory chapter “The Evolution of Intelligence: A Multi- and Interdisciplinary Review of Concepts and Practical Applications,” *Rainer M. Holm-Hadulla* (medicine, psychiatry and psychotherapy) and Hannes Wendler (philosophy, psychology) indicate the deep structure underlying the individual contributions and discuss the ways in which they interconnect to an integrative concept of intelligence.

The articles are listed here in alphabetical order (in the volume itself, they are grouped under the seven headings set out in the Introduction).

Ines Al-Ameery-Brosche and *Franz Resch* (child and adolescent psychiatry) point out in their contribution “Emotional Robotics: Curse or Blessing in Psychiatric

Care" the dangers as well as the advantages of "social robots" and medical IT applications, which can be seen as tools but not as substitutes for human attention.

Theresia Bauer (minister for science, research and the arts of the state of baden-Württemberg, Stuttgart) provides a practical report from the world of political action in the chapter "Political Intelligence? A view from practice between politics and science." Wisdom and trust in science play an important role here.

Michael Byczkowski (SAP) and *Magdalena Görtz* (urology) write on "The Industrialization of Intelligence," using medical examples to show how the interplay of observation, experience, cognition, and skills leads to intelligent insights.

Andreas Draguhn (physiology) describes the "Neurobiology of Intelligence" and deals with an essential biological correlate of intelligence: the brain. Important framework conditions for genetically based "biological" intelligence show that good physical conditions, diverse stimuli, and conducive social interactions in the first years of life are favorable for its development.

Claudia Erbar and *Peter Leins* (biology) take an evolutionary perspective in their article "Intelligent play with chances and selection" and use numerous examples to show intelligent constructions of evolution as they are used today by bionics.

Klaus Fiedler, *Florian Ermark,* and *Karolin Salmen* (social psychology) use the term "metacognition" to outline potential errors and deceptions in rational judgment and decision making in the fields of law, medicine, and democracy. Quality control applied to one's own thinking is called for.

Dietrich Firnhaber (Covestro AG, Leverkusen) takes a close look at strategic planning for dealing with uncertain facts in his article "Intelligent handling of complexity by companies." He shows that uncertain knowledge about known uncertainties can be used productively.

Thomas Fuchs (philosophy and psychiatry) concludes in "Human and Artificial Intelligence: A Critical Comparison" that human intelligence is something specifically human that cannot be placed on the same level as artificial intelligence, i.e., algorithm-driven machine data processing.

Joachim Funke (general psychology) describes in "Intelligence: The Psychological View" different conceptions of the construct and at the same time points out its "dark side," i.e., the destructive potential of intelligent action.

Sebastian Harnisch (political science) takes a look at the concept of "political intelligence and wisdom." The historical roots of these concepts are set out, as are current developments in the twentieth/twenty-first century.

Sabine C. Herpertz (psychiatry and psychotherapy) distinguishes in her chapter on "Interpersonal Intelligence" between mentalization, empathy, and caring. She describes their neurobiological correlates and draws practical consequences.

Vincent Heuveline (mathematics) and *Viola Stiefel* (computing centre) describe in their contribution "Artificial Intelligence and Algorithms: True Progress or just Digital Alchemy?" the basics of AI and the limits of its possible applications. They advocate improvements in AI competencies, e.g., in the school sector, and at the same time sensible and sensitive handling of AI from ethical and ecological perspectives.

Thomas W. Holstein (molecular biology) assumes that the entire cellular and molecular repertoire of our nervous system was already formed in earlier evolutionary stages over 500 million years ago. The ability of neuronal systems to carry out cognitive decision-making processes enables associative learning and intelligent problem-solving even in organisms that we consider to be simple, such as marine snails. Specific genes play a central role in this process. Comparative genomic studies make a decisive contribution to the understanding of brain evolution.

Magnus von Knebel Doeberitz (tumor biology) presents new possibilities for artificial intelligence in the field of medicine. Many current advances in medicine would not be possible without AI. He supplements the *Internet of Things with* an *Internet of Medicine*.

Katajun Lindenberg and *Ulrike Basten* (child and adolescent psychotherapy) describe from a clinical perspective the "Development of intelligence in relation to the use of digital media." Given the increasing use of digital media by children and adolescents, the advantages and disadvantages for their mental development are discussed here in the shape of an overview article.

*Vera Nünning (*cultural studies) takes up our framework topic in her contribution "Intelligence in and with Literature" by analyzing its representation in two recent novels by Ian McEwan and Kazuo Ishiguro, thus making the powerful experiential world of literary writing comprehensible for the understanding of self and world.

Manfred Oeming (theology) makes clear in his contribution "Intelligentia Dei" the science-friendliness of the Bible. On the other hand, he warns against too much faith in technology and the "promises of salvation" held out by some apologists of artificial intelligence.

Gudrun A. Rappold (genetics) describes what happens "when intelligence is impaired." Using autism as an example, she illustrates genetic mechanisms that negatively influence the development and function of neuronal networks and circuits but are also susceptible to treatment if detected early.

Robert J. Sternberg (cognitive psychology) in his article "Meta-Intelligence: Understanding Control, and Coordination of Higher Cognitive Processes" asks whether various higher processes of cognition cannot be grouped under the umbrella term "meta-intelligence."

Thomas Stiehl and *Anna Marciniak-Czochra* (mathematics) deal with the topic "Intelligent algorithms and equations? - An approach to the intelligence of mathematical concepts" and indicate analogies between human intelligence and the intelligence of learning algorithms. The parameter estimates and the resulting predictions achievable with computer simulations make complex issues manageable.

Christel Weiss (medical statistics) outlines in her historically oriented chapter "Statistics and Intelligence: a Changing Relationship" the development of statistical methods in the context of "measurement of intelligence" and also deals with the intelligence of data, methods, users, and consumers of statistics.

Michael Wink (biology) looks at "Intelligence in Animals" and provides many examples of intelligent behavior such as hammering, fishing, and poking. Animals are capable of amazing cognitive feats (problem-solving, cognition, memory and orientation, etc.) and of social behavior.

We would like to thank Hannes Wendler for his assistance with the manuscripts.

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Rainer M. Holm-Hadulla
Joachim Funke
Michael Wink

Reference

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Contents

About the Editors

Rainer M. Holm-Hadulla, MD is a professor of psychiatry, psychosomatic medicine, and psychotherapy at the University of Heidelberg and the Universidad de Chile, among others. He also works as a counsellor and training psychoanalyst (IPA). In his functions as a professor and as a clinician he was confronted with various forms of intelligence and creativity. He reflected his experiences under neuroscientific, psychological and cultural perspectives in several German books: "Creativity – Concept and Life-Style," "Creativity between Construction and Destruction," "Passion – Goethe's Path to Creativity" (available also in English, Spanish, and Italian), "Integrative Psychotherapy" (also available in Italian and English with the title "The Recovered Voice – Tales of Practical Psychotherapy"), "The Art of Counselling and Psychotherapy" (available in English and Spanish).

Joachim Funke has been Professor of general and theoretical psychology at the Psychology Department of Heidelberg University since 1997. He received his doctorate from the University of Trier in 1984. In 1990 he worked on his habilitation at the University of Bonn. Funke has been a visiting professor at various universities, including Fribourg (Switzerland), Melbourne (Australia), Nanjing (China), and Szeged (Hungary). His primary research interests include thinking, creativity, and problem solving. Funke has published numerous articles in international journals, contributed chapters to textbooks, and edited and published his own books. From 2010 to 2014, he served as chair of the International Expert Commission on Problem Solving in the OECD's global PISA studies. He is credited with a shift in the understanding of problem solving that changes the perspective from static to dynamic problem-solving activities. In 2015, he was awarded an honorary doctorate by the Hungarian University of Szeged for his contributions to the computer-based assessment of problem-solving processes. From October 2011 to March 2019, Funke served as speaker of the university's Academic Senate. His retirement began in April 2019.

Michael Wink is a full time professor of pharmaceutical biology at the University of Heidelberg, where he has served as the head of the Biology Department at the

Institute of Pharmacy and Molecular Biotechnology since 1999. He has been working as a senior professor at Heidelberg University since late 2019. After studying biology and chemistry at the University of Bonn, he conducted research in Braunschweig, Cologne, Munich, and Mainz. His fields of work range from phytochemistry, medicinal and poisonous plants, ornithology and natural treasures to systematics, phylogeny, and evolutionary research. He is extensively published, as an author/co-author of more than 20 books and over 1000 original papers. He is a visiting professor at universities in China, Thailand, Argentina, and Mexico, as well as a member of various scientific advisory boards, editor of several journals, and recipient of several awards.

Chapter 1
The Evolution of Intelligence: A Multi- and Interdisciplinary Review of Concepts and Practical Applications

Rainer M. Holm-Hadulla and Hannes Wendler

Abstract Intelligence enables us to understand events and to shape our environment. It is a heterogeneous ability, and in the following we shall be discussing various attempts undertaken by individual scientific disciplines to define and explain it. In our outline of the evolution of intelligence, one major focus is on interdisciplinary connections, a focus that can be expected to deepen our understanding of the subject (especially with regard to its practical consequences). In our multidisciplinary approach to the evolution of intelligence, we identify several levels of intelligence. The higher levels are grounded in, and built on, the lower levels, with respect to which they not only increase in complexity but also display differences in kind. (1) Biological intelligence is concerned with vital processes and the co-adaptive interplay of an organism and its environment. (2) Psychological intelligence encompasses various faculties (cognition, emotion, efficacy, etc.) at the level of the individual person and is not identical with "what the intelligence test measures" (as the operationalist position would put it). (3) Mathematical intelligence attempts to model and describe intelligence in formal terms. (4) Artificial intelligence is concerned with the synthetic or virtual re-creation of known models of intelligence and, similar to biological forms of intelligence, sheds comparative light on the specific nature of human intelligence. (5) Cultural intelligence designates ways of relating to the world that are sedimented in creative products and catalyze intelligent acts of an individual nature. (6) Political intelligence (and political wisdom) refer to holistic

Our sincerest thanks go to Andreas Draguhn, who provided extensive, concise and – last but not least – critical comments on this article. The quality of the section on biology and the overall clarity of the text have profited especially from his clear-sighted remarks.

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deliberation and practical decision-making, i.e., coming to terms with the complexity of our life-world and responsibly engaging with it and its inhabitants. Viewing intelligence against the backdrop of these six levels in its evolution foregrounds the fact that any true understanding of each of these forms of intelligence must pay due heed to the other varieties. The same rationale holds for the practical application of intelligence.

1 Introduction

The first issue of *Nature*, still one of the leading scientific journals of our time, begins with an aphorism attributed to Goethe: "Nature! We are surrounded and embraced by her: powerless to separate ourselves from her, and powerless to penetrate beyond her … She has neither language nor discourse but she creates tongues and hearts by which she feels and speaks." (Huxley, 1869, p. 9). In this same vein, scientists from various disciplines attempt to describe and understand the nature of intelligence with "tongues and hearts," i.e., as a human property.

The term "intelligence" is a term used equally in scientific and everyday language. It comes from the Latin "*intelligentia*," which can be translated not only as "insight" or "understanding" but also as "connoisseurship." The term contains the verb "*legere*" which means "to gather, collect, select, choose". Finally, "*intellegere*" can be rendered as "to perceive, recognize, see, realize, understand, comprehend." Thus, the term refers to a variety of mental processes, behaviors, and interactions. We suggest that intelligence occurs at different levels that are the domain of different scientific disciplines and perspectives. However, these levels are not only hierarchically organized but permeate each other, necessitating an interdisciplinary concept of intelligence. Let us begin with the first level of intelligence regarded from the vantage of the natural sciences.

2 Biological Foundations

From a modern scientific perspective, humans no longer appear to be the only species that possesses intelligence. Cognitive abilities worthy of the name are attributed to other species such as primates, whose brains exhibit significant similarities with those of humans. However, creatures without a brain mantle (neocortex), such as carrion crows, can also solve tasks intelligently and do no worse in this respect than apes (Nieder et al., 2020). Recent studies even attribute intelligence to cephalopods (Albertin et al., 2015; Godfrey-Smith, 2016; Schnell et al., 2021). This suggests that the evolutionary development of powerful brains began at an early stage indeed. The common genetic, molecular, and cellular constituents of nervous systems took shape more than 500 million years ago (Holstein, this volume). Consequently, a true understanding of the diversity of brain architectures requires comparative approaches in the field of *genomics* that reflect the divergent evolution of existing species (see, e.g., Mao et al., 2021). In line with the widely stratified character of intelligence, such studies must however be supplemented by anatomical, physiological, behavioral, and cognitive approaches (Dicke & Roth, 2016; Hofman, 2019).

Current neurobiological findings show how different brain architectures (and hence behavioral–cognitive abilities) have evolved as a response to different niche requirements and environmental constraints. This is visible even in rather simple neuronal systems arising from the same basic cellular elements—electrically active neurons—as complex brains (Holstein, this volume). Networks formed by interconnected neurons form a material substrate for the cognitive decision-making processes underlying associative learning, behavioral flexibility, and "intelligent" problem-solving. This holds even in what we consider to be simple organisms, such as the sea snail *Aplysia californica* (Kandel et al., 2000). The relatively small number and large size of the neurons these animals possess make them excellent subjects for detailed studies of the biological, chemical, and physical processes associated with cognitive performance. However, analytic methods at the cellular and molecular level alone cannot explain the specific properties and cognitive–behavioral function of neural systems and the *emergent* functional properties they develop at the levels of networks, nervous systems, and organisms (Holstein, this volume).

One major principle governing the evolution of organisms is that of natural selection, i.e., higher differential reproduction of those conspecifics that are better adapted to the respective environment—so-called fitness (Darwin, 1859; cf. Mitchell, 1987). To a certain degree, however, human intelligence has emancipated itself from this principle, because it is also subject to cultural evolution, a process which is, in turn, heavily influenced by human intelligence itself, resulting in a circular process of self-adjustment of the evolutionary forces operative in human development (Tomasello, 2009; Deacon, 2012). This is most evident in the development of art, ethics, and morals. We will come back to this later. Drawing on Darwin's evolutionary optimization principle, Erbar and Leins (this volume) show that even plants make use of an evolutionary "box of tricks." Plants can imitate, deceive, and kill, although there is no evidence for the involvement of any genuine cognitive processes, let alone conscious intention, in what they "do." In fact, it is the flexible adaptation of plants to their environment that gives rise to apparently tailor-made reactions that are sometime called "intelligent" (Erbar & Leins, this volume). They are not, however, rooted in complex representations and cognitive operations within a nervous system. Scientific disciplines like bionics learn from this natural "box of tricks," which helps them to build complex technologies from robotics to artificial intelligence.

Animals, especially those with high behavioral flexibility, exhibit genuine intelligence (Wink, this volume). Many species recognize causal relations, make plans, and find unprecedented solutions. This is particularly evident in the use of tools. Some examples of tool use are genetic, others are acquired, and for the most part "nature" and "nurture" go hand in hand. Not only apes but also other species such as birds have social networks through which they pass on their practical knowledge to conspecifics. Even though tool use demonstrates that such animals are capable of abstraction, generalization, problem-recognition, and problem-solving (Wink, this volume), it seems hardly possible for them to think at the same level of abstraction as humans, i.e., to create abstract theoretical constructs, ethical, scientific or religious systems, or to philosophize. To the best of our knowledge, no species other than humans construct models designed to explain themselves and the world (see below).

However, even the most sophisticated forms of human thinking are limited by natural conditions, as we can see from the cognitive and behavioral consequences of brain disorders. Though neuroscience has made great progress in defining the natural conditions of intelligence, we are still far from understanding them completely. Physiologist Andreas Draguhn proceeds from this definition: “Intelligence is the ability to solve problems through flexible acting or thinking. Acting and thinking are meant, here, as intentional acts that go beyond purely reflexive automatisms, i.e., as actual agency” (Draguhn, this volume). The adaptation of a living being to its habitat is not sufficient to qualify as intelligence. Only living beings that can actively choose between alternatives can be regarded as intelligent. This form of intelligence is bound up with a central nervous system which, in turn, is made up of the same elements and mechanisms as simpler brains.

Draguhn emphasizes that there is no straightforward answer to the question of how pronounced brain development in hominids came about in the course of evolution. Hofman (2019) summarizes the physical and socio-cultural conditions of this development. New developments in environmental conditions such as climate changes and food scarcity elicited constant adaptations. At the same time, group formation and the learning of social skills were crucial factors in the evolution of human intelligence. This was accompanied by the emergence of language, which expanded the scope of imagination and hence the realms of thought (Draguhn, this volume). In this way, brain and culture co-evolved (Deacon, 2012; Sterelny, 2012; Haidle et al., 2015).

Human intelligence and the emergence of culture are hence associated with the evolution of the brain. Indeed, various cognitive abilities are located in specific parts of the brain. The neocortex is associated with thinking and consciousness. Its volume in humans, especially in the frontoparietal area, is much larger than in primates. To simplify, one could say “that (pre)-frontal parts of the brain are particularly concerned with action, decision-making, and rational impulse control, whereas the parietal cortex integrates multimodal sensory and motor impulses and in this way generates our picture of the current context” (Draguhn, this volume). One could also describe these “association areas,” which are independent of immediate perception and action, as the pinnacle of cognition. Of course, localization theories are always a simplification, and one should not forget that these areas never work on their own but only in dynamic interaction with others, e.g., the thalamus, the basal ganglia, and the limbic system.

Research into the fine-grained structure of neuronal networks reveals various anatomical properties that are important for intelligence. In particular, the number of neurons and synapses are relevant, as is the thickness of the axons. The latter determines the transmission speed of impulses that enable fast and complex information processing. Non-neuronal cells in the brain, called glia cells, also contribute to this. All levels of our neuronal networks are in constant interaction, i.e., the activity of single neurons affects the activity of local networks involved in large-scale activity patterns of the whole brain. Causality is both bottom-up (neurons causing brain-wide activity and behavior) and top-down (behavior and experience entraining the activity of neurons and their synaptic connections). The functions of the brain are reflected in micro- and macro-structures. For example, the folding of the cerebral cortex allows for high local connectivity, which is partly responsible for processing speed and thus for complex thought processes. In line with Fodor (1983), we can say that it is precisely the brain's modular architecture that enables the structural and functional specializations of different areas (Hofman, 2019). Here, clear differences between species become apparent, e.g., Fodor's classical examples of language and (primary) visual processing (cf. Pylyshyn, 1999; Firestone & Scholl, 2016).

As an area of particular importance for "higher" cognitive functions, the human prefrontal cortex is particularly large and rich in cells. It appears to be of key importance for complex thinking and rational decision-making, serving as an organ for "executive control" and "top-down regulation." Similar to all other brain areas, it is not autonomous but is always influenced and regulated by "bottom-up" input from other areas. For the same reason, it is a highly biased, simplified, and anthropocentric view to take the increasing "frontalization" of the brain from "lower" mammals to humans as proof of our rational nature and the superior position of humans in the animal kingdom. The interdependence of the frontal cortex with other brain areas, with the whole organism, and even with the social environment also highlights its ecological dependencies. The brain never works alone but exercises its functions in the context of our experiences and actions as holistic beings. For example, research on neuronal plasticity shows an astonishing, life-long capacity for intellectual development that stems from being embedded in, and interacting with, supportive surroundings (Monyer & Gessmann, 2017).

The findings of neuroscience indicate the conditions conducive to the development of intelligence: secure environmental conditions in conjunction with developmental incentives; early promotion of the ability to think and the capacity to act through learning and practice; repetition (e.g., by memorization) and stimulation of new neural connections (e.g., through musical activity); an appropriate balance between concentration and distraction, focused and associative thinking, and the interplay of coherence and incoherence in neuronal networks (see Holm-Hadulla, 2013).

In short, human intelligence and culture are rooted in our biological make-up, most of all in the structure, functioning, and interactions of the brain. However, it is impossible to reduce the most complex acts of thinking and, even more, the emergence of sophisticated cultural systems such as music, art, philosophy, religion, science, and technology to biological functions only. They emerge at their own levels of complexity, requiring their own, non-biological tools to analyze them and languages to describe them. As a first step in substantiating this conviction, we turn to the psychology of intelligence.

3 The Psychology of Intelligence

Despite increasing insight into the biological and neuroscientific foundations of intelligence, there are still domains of such complexity that they can no longer be explained by physical, chemical, and biological methods—especially in the human sphere. Accordingly, a science has emerged that for over a hundred years has chosen intelligence as one of its central topics: psychology (Funke, this volume).

In 1905, Binet and Simon developed one of the first intelligence tests designed to diagnose and study mental disabilities (see Funke, this volume). In the United States, this test was introduced by Terman as a way of selecting personnel for the intelligent use of complex military technology. At about the same time, Spearman developed a "two-factor theory" that distinguished specific factors of intelligence, such as computational or linguistic ability, from a general intelligence factor. Thurstone (1973), on the other hand, considered this general factor to be a statistical artifact and conceived of intelligent behavior as the interaction between several independent primary abilities: verbal comprehension, word fluency, reasoning, spatial awareness, retentiveness or memory, computational ability or number memory, and perceptual speed or attention (see Funke, this volume). Numerous further developments in the conception and measurement of intelligence followed in the course of the twentieth and twenty-first centuries (see, e.g., Sternberg, 2018). The most common intelligence test today is the Hamburg-Wechsler Intelligence Test (HAWIE, since 2013 WAIS-IV), which is used in different forms for children and adults.

At the theoretical level, Gardner's concept of multiple intelligences is particularly important (1983). According to his research, nine dimensions of intelligence can be distinguished empirically: linguistic, logical–mathematical, musical–rhythmic, pictorial–spatial, bodily–kinesthetic, naturalistic, interpersonal, intrapersonal, and finally existential intelligence (in the sense of wisdom). Especially when it comes to emotional and social intelligence, established measurement methods tend to be overly simplistic compared to the complexity of the functions measured. Funke (this volume) suggests that psychological intelligence research should concern itself less with structures and more with processes, and that more realistic, life-like conditions should be taken account of in tests. These include high complexity, interconnectedness, momentum, obliquity, and multiplicity coupled with a need for multi-dimensional information processing.

Furthermore, Goleman's (2020) notion of emotional intelligence has become widely accepted. It describes the ability to perceive, understand, and influence one's own and others' emotions. One aspect of emotional intelligence is so-called interpersonal intelligence, which already played an important role in Gardner's thinking. Herpertz (this volume) distinguishes a (meta-) cognitive and an emotional component of interpersonal intelligence. The former refers to the ability to adopt other perspectives, i.e., to understand and also anticipate the mental states of others. This reflective perspective is bound up with specific cognitive functions and linguistic expressions and is also referred to as mentalization (Fonagy & Allison, 2012), mind-reading (Goldman, 2006), theory of mind (Premack & Woodruff, 1978), or (cognitive) empathy (Lipps, 1905). The emotional component consists of resonant intuitive empathy based on a kind of direct perception of the way another person's mental life is reflected in his or her expressive behavior (Zahavi, 2014). Neurobiologically, mentalization correlates with activity in cortical midline structures and temporoparietal areas (Herpertz, this volume), whereas resonant intuitive empathy correlates with processes in areas established earlier in our evolution such as the sensorimotor cortex and the anterior insular region. Especially the imitative aspect of affective empathy is closely linked to the so-called mirror neurons (Gallese et al., 1996), i.e., the neuronal substrate that "fires" in a similar way whether a certain action is observed in someone else or carried out by oneself. Mirror neurons have been investigated in great detail by research programs based on a wide range of concepts such as embodied simulation theory (Gallese & Sinigaglia, 2011) or phenomenological anthropology (Breyer, 2015). Ontogenetically, mentalization and empathy are learned through close interaction with early caregivers. Mirror imitation of affective and sensorimotor states can already be observed in the first year of life. It later develops into an intuitive and embodied understanding of the affects and feelings of others (Herpertz, this volume). Processes of joint attention (sharing the focus of attention with others) occur toward the end of the first year of life, and mentalization capacity develops further from there (Tomasello, 2019) (see Fig. 1.1).

Fiedler et al. (this volume) address the question of why human judgment and decision-making so often deviate from the rules of logic. Kahneman and Tversky (1986) have famously highlighted the apparent shortcomings of human intelligence

Fig. 1.1 Mother with child; watercolor by Christel Fahrig-Holm. (Reprinted with permission of the artist)

in countless experiments. However, seemingly irrational behavior can also be adaptive and purposeful, they argue. This perspective has been developed further, re-conceiving seemingly faulty heuristics and irrational biases as "fast and frugal" cognitions adapted to particular features of the environment in which decisions are made (Gigerenzer, 2001). We speak of bounded rationality when cognitive capacities are matched to specific environmental demands, as famously illustrated by the availability of recognition heuristics (Todd & Gigenrenzer, 2007).

The flexible transfer of skills to new domains presupposes an ability that Fiedler et al. (this volume) call "metacognition." It monitors, controls, and corrects other cognitive processes. However, deficits in monitoring and controlling one's mental operations are widespread. The authors' term such deficits "metacognitive myopia," which can be a serious obstacle to rational behavior. As examples they refer to uncritical inferencing, counter-productive perseverance, and the disinclination to avoid learning and remembering information known to be false. Awareness of metacognitive myopia is of great practical importance, e.g., in evaluating testimonies and political decisions. Ways of improving metacognitive intelligence include quick and clear feedback, incentives for improvement, and preemptive perpetuation of reliable information. However, metacognitive myopia still remains a major obstacle to rational thought and action. It is puzzling why we often lack the critical judgment required to distinguish false information and obvious fake news from trustworthy sources. The authors advance the interesting hypothesis "that evolution may not have 'forgotten' to strengthen metacognition at all, but may have 'deliberately' suppressed it … The constant attempt to scrutinize and critically test the durability of any information may mean sacrificing a number of other foundations of adaptive intelligence, such as trust in social information, parsimonious heuristics, and rapid automatic priming effects."

4 Mathematical and Artificial Intelligence

The mathematicians Stiehl and Marciniak-Czochra (this volume) define intelligence as a general ability that encompasses reasoning, planning, problem-solving, abstract and complex thinking, and learning from experience. They show that mathematical or algorithmic structures can realize such abilities in an abstract way. For our purposes, this means that there are levels of intelligence that demand to be recognized as such but do not patently depend on biological substrates. This transfer of the concept of intelligence from living beings to ideal, mathematical structures require us to pay close attention to both the transformations that the concept of intelligence undergoes in this process and the degree to which such a transfer is justifiable in the first place.

Above all, mathematical and artificial intelligence play a role in processes that are not readily accessible to intuitive and associative approaches to human intelligence, either because they are too complex, the relevant variables are unknown, or the volume of underlying data exceeds human processing capacity. Mechanistic modeling is an essential element in mathematical intelligence. It is the translation of the items, mechanisms, and processes of a system or issue into formal objects that can be studied using mathematical or computational techniques (Stiehl & Marciniak-Czochra, this volume). Mechanistic modeling can be applied in physics, chemistry, and biology as well as in medicine and economics. It permits the intelligent utilization of complex concepts and even takes account of learning from experience. Of course, mathematical "learning from experience" is not comparable with the way humans incorporate experience into their skills and intelligence. It is best thought of as a stochastic form of adaptation that remains dependent on the intelligence of the mathematicians who pre-define the range and rules of experience-dependent changes. But mechanistic models enable us to predict events, derive conclusions from experience, plan strategies, and solve problems. When they are combined with data-driven techniques such as "machine learning," they help us to model and integrate multiple variables that would otherwise be incomprehensible. It needs to be emphasized that the "meaning" or significance of data only reveals itself through adequate statistical analysis and intelligent interpretation (Weiß, this volume). Data cannot think, nor can they work out solutions independently. Only if we can understand how data are collected, estimate their scope, and establish how they can be used intelligently, can data contribute to the explanation of events and relationships. In the sciences, one of the most important, methodologically sound ways to achieve such intelligent interpretation of data is by the use of models that further the understanding of complex systems and support the generation of hypotheses.

Heuveline and Stiefel (this volume), director of the "Mathematikon" at the University of Heidelberg, argues that artificial intelligence (AI) is first of all a metaphor for decisions driven by algorithms. So-called weak or narrow AI is equivalent to applied mathematics. Weak AI can surpass human intelligence in some areas but is in fact fundamentally different in nature. It encompasses all systems in existence today, for example, those we are familiar with from image and text recognition. So-called strong intelligence, on the other hand, sets out to imitate human intelligence. From a mathematical point of view, there are fundamental reasons why this cannot succeed. Ambitions of this nature will remain science fiction (Heuveline & Stiefel, this volume). There are fundamental differences between mathematical and human intelligence, e.g., concerning the embodied and emotionally resonant understanding of biographically toned moods (see Herpertz, this volume; Fuchs, this volume; Oeming, this volume). This notion, however, does not diminish the importance of AI in specific domains. The benefits of AI in handling the exponentially growing volume of data worldwide are not only striking but also indispensable in this age of "big data."

Because of the importance of AI for society as a whole, Heuveline wants an understanding of algorithms to be integrated into school education. Teachers and pupils need to be informed about the technical potentialities and limitations of AI, as well as the ethical considerations involved and the legal regulations required. One important role of human intelligence in the field of AI is that of safeguarding self-determination and data sovereignty. Further investment in AI is essential, especially in the field of ecological AI or "green IT."

5 Artificial and Human Intelligence

Psychiatrist and philosopher Fuchs (this volume) investigates the fundamental differences between artificial and human intelligence. He proceeds on the assumption that advances in AI and robotics cast increasing doubt on the distinction between simulation and reality. He rejects the idea that social technologies, e.g., as envisioned by the behavioral psychologist Skinner, promise greater happiness for society by means of the technical conditioning of humans. The idea that rational knowledge and corresponding technologies can free humankind from the irrational self-image it is laboring under is also written into plans to increasingly replace human intelligence with AI. According to Fuchs (this volume), the prerequisite for human intelligence is interaction between the living (perceiving and acting) organism and its environment. Human intelligence is fundamentally based on human life. Consequently, it is nonsensical to try to conceive of humanity in terms of information-processing and information-storing strategies gadgets run by electronic algorithms.

If one reduces the human mind and its embodiment in the whole organism to logical operation processes in the brain, analogous to the functioning of computers, serious errors are bound to arise. Most notably such a view is *cerebrocentristic*, i.e., it reduces human intelligence to processes taking place in the brain and consequently cannot adequately account for its grounded nature (Barsalou, 2008). In the light of research on grounding and 4E-cognition (embodied, enacted, extended, embedded), the famous "brain in a vat" appears to be ill-conceived: intelligence presupposes a body in the world (Thompson & Cosmelli, 2011). Furthermore, conceiving of the human mind as analogous to a computer runs the risk of repeating de La Mettrie (1747/1999) notorious "*homme machine*," depriving the human mind of its vitality and its phenomenalistic qualities. On top of that, such a computationalist understanding of the human mind models person-level properties and activities by ascribing the same phenomenological properties (thinking, perceiving, etc.) to sub-personal processes within the brain. The old *homunculus* problem can be descried lurking in the background behind this argument, i.e., we merely transfer the problem to another level, proposing the existence of a "human" or "person" inside our heads. In terms of the language of computationalism, we would do better to conceive of this is as a machine within a machine.

In a similar vein, and harking back to Galileo, Descartes, and Leibniz, Fuchs (2020) criticizes the "idealism of information" that has enjoyed ever greater currency in modern information technology since Alan Turing. Here, thinking is defined as purely connectionist, i.e., in terms of physical processes. It is an approach that encourages the reification of complex life processes and empathic social encounters. Unlike AI, human thinking is inconceivable without inter-corporeal experience. From infancy onwards, the development of human intelligence has to be thought of in terms of "living intersubjectivity." Accordingly, we should never forget that there is a major distinction between scientific intelligence and AI on the one hand and life-world intelligence and embodied social intelligence on the other. In ideal cases, this tension can be productively transformed so that new insights and recommendations for action can be derived from it through dialectical communication (see Holm-Hadulla, 2013, 2020).

AI is increasingly permeating all spheres of science and of social and economic life. Byczkowski and Görtz (this volume) show how AI, especially modern algorithmic approaches, fits in with the basic concepts of observation, experience, cognition, and skill. While not furnishing any complex models for "explaining" the world, the major advances in the field of AI support scientific progress and offer useful practical applications. According to Byczkowski and Goertz, the Industrial Revolution can be divided into four phases: the use of mechanical production equipment, production based on the division of labor, automation of labor, and now the so-called Fourth Industrial Revolution adumbrating fully digitalized and interconnected production. In light of the advances made by AI, it is also possible to conceive of a Fifth Industrial Revolution. Taking medicine as an example, Byczkowski and Görtz (this volume) highlight the opportunities and challenges of AI and intelligent machines. Their conclusion is that AI algorithms will be an integral part of our lives to a larger degree than they already are today. In this context, it is crucial not to think of machines as competitors or enemies, but rather as a potential way of enriching and expanding the horizon of our life-world via technology.

6 Cultural Intelligence

In analogy to "cultural memory" (Assmann, 2011), we speak of "cultural intelligence" when we refer to cultural assets like thinking, judgment, or creativity. Unlike biological intelligence, the cultural variety is embedded in cultural landscapes, architectures, myths, religions, literature, music, visual arts, and other artifacts. Accordingly, it cannot be properly understood using the methods applied by the natural sciences. Cultural intelligence is the expression of a relationship *sui generis* between humankind and the world. In contemporary evolutionary theory, it is commonly accepted that the co-evolution of human nature and human culture has resulted in a unique dynamic through which cultural influences can rapidly exert very strong and lasting effects on human thinking. This encompasses the so-called "ratchet effect," which refers to an accumulation of modifications in our cultural environment that result in an exponential growth process also known as "cumulative culture" (Tennie et al., 2009; Haidle & Schlaudt, 2020). In light of the dynamic nature of cultural intelligence, anthropologists have little choice but to acknowledge that human infants are at least as well adapted to a "symbolic environment" as they are to their natural environment (Tomasello, 2009; Deacon, 2012).

In contemporary cultural studies, culture is understood as "the total complex of ideas, forms of thought, ways of feeling, values, and meanings that materializes in symbol systems" (Nünning & Nünning, 2008, p. 6). Cultural studies will thus necessarily deconstruct traditional certainties. For example, "race," "gender," and "colonization" have become major topics for scholarly reflection and cultural practice.

These examples illustrate the connection between intelligence, wisdom, and ethics. Literature, for example, can expose stereotypes and unjustified hierarchies based on prejudices about the differences between female and male intelligence. Intellectual skills, and especially emotional and social intelligence, can be enhanced by engagement with works of literature. Readers gain insights into cognitive and affective processes that might otherwise have remained a mystery to them. This can lead to changes in attitudes, e.g., about the relationship between instrumental intelligence, wisdom, and ethics. In her discussion of the novels "*Machines Like Me*" by Ian McEwan and "*Klara and the Sun*" by Kazuo Ishiguro, Nünning (this volume) addresses particular problems associated with the decoupling of intelligence, wisdom, and ethics. These texts invite complex reflections on the relationship between analytical and emotional intelligence as well as human and artificial intelligence. They demonstrate that intelligence alone is not sufficient for responsible action. Wisdom and ethics are just as essential (see below).

Cultural intelligence is an aspect of a holistic species of understanding for which we suggest coining the term "life-world intelligence." It is based on everyday experiences in the concrete life-world of individuals and communities very much along the lines of what the ancient Greeks called *phronesis*, i.e., the wisdom of practical life (Aristotle, 2006). Instrumental action, complex thinking, and living intersubjectivity endow us with a feeling of self-efficacy and coherence because they actually help us in coping with the challenges of everyday life (see Holm-Hadulla, 2021). It is a feeling and a conviction that are invariably rooted in a larger cultural whole governed by a different logic than the life-world of individuals.

Scientist, politician, and poet Johann Wolfgang von Goethe is a paradigmatic instance of the importance of cultural intelligence for understanding our life-world and its realities. In his *Faust*, which he worked on over a period of 60 years and has lost none of its relevance to this day, he confronts us with the limits of scientific knowledge: "Have now, alas! studied philosophy/jurisprudence and medicine, /And, alas, also theology/thoroughly, with hot endeavor. /There I stand, poor fool, /And am as wise as before!" (*Faust I*, "Night").

With his poetic resources, Goethe attempts to understand the reality of life and in so doing points up interesting and novel perspectives for the sciences. The topics he enlarges on are astonishingly modern. From an economic perspective, he deals with the risks involved in borrowing without securities, which leads to a "miraculous multiplication of money" (*Faust II*, Act 1, "Large Room"). From an ecological perspective, Goethe's critical appraisal of unchecked expansionism and the ruthless appropriation of land at the cost of human lives, natural resources, and traditional values has gained ever greater relevance (*Faust II*, Act 5, "Open Area"). Even AI and robotics are pre-figured in the *topos* of the creation of the "homunculus" (*Faust II*, Act 2, "Laboratory").

Poetry, art, and music are not merely educative, they also help us to cope with, recognize, and overcome emotional, intellectual, and social conflicts. The arts are essential in transforming hatred and violence (see Holm-Hadulla, 2019). Their cognitive and coping function is still evident today in prominent examples like the painter Gerhard Richter, musicians like Madonna or the Rolling Stones, and poets like Amanda Gorman (2021). Madonna seeks solutions to historical traumas and religious questions and develops considerable social impact by shedding light on social injustices, especially the oppression of women and their sexuality, through provocative depictions that for many are anything but tasteful. In their song "*Sympathy for the Devil*," located somewhere between Bulgakov's *The Master and Margarita* and Goethe's "power which always wills evil and always creates good," the Rolling Stones address historical atrocities. Their song describes various forms of human destructiveness. It covers topics such as the crucifixion of Jesus Christ, the murder of the Tsar's family after the Soviet October Revolution, the Hundred Years War between England and France, the ritual murder of troubadours in India, and the assassinations of the Kennedy brothers. The essential message is that evil must be faced if it is to be overcome (Holm-Hadulla, 2019).

Goethe speaks of the healing potential of artistic and musical intelligence: "Sad is our mind, confused are our endeavors; /how the lofty world fades away from our senses!/And then music hovers by on its angel's wings, /interweaving one tone with another into millions, /in order to penetrate man's being through and through, to fill him over-abundantly with eternal beauty …" (Appelbaum, 1999, p. 206).

Thus, music can be seen as a spiritual refuge where we learn that the experience of beauty is vital for a good life. Reflection on the cognitive foundations of beauty has a long-standing tradition in our culture, going back at least to Plato, and would require a separate treatise. Of course, this is not restricted to music but also applies to the visual arts. Gerhard Richter, for example, explores his personal biography by engaging with contemporary history in his paintings. Encounters with art can bestow flashes of insight that cannot properly be grasped scientifically. Shakespeare sums this up in a way that remains fully valid to this day: "Such shaping fantasies, that apprehend/More than cool reason ever comprehends." (Shakespeare, *A Midsummer Night's Dream*, Act 5, Scene 1).

Just like scientific knowledge, cultural and artistic knowledge needs to establish a connection with practical life if it is to serve as an ethical guide for human action. History is rife with art that has been exploited to spread hate and violence instead of trusting to its poetic transformation of the world. Richard Wagner's mythical motifs are an extreme example of this. They were appropriated by Adolf Hitler and his henchmen for a politics of immorality that considered itself "artistic" (Fest, 2002). Nevertheless, artistic intelligence remains essential for the creative transformation of destructiveness. We see this in the transformative intelligence informing the composition of Botticelli's *Birth of Venus*. The painting shows how Aphrodite—the equivalent of the Roman Venus—is born from the foam of the waves and carried ashore by a shell (see Fig. 1.2). In the myth, however, Aphrodite, the goddess of beauty and fertility, has much more sinister origins. Part of Botticelli's accomplishment resides precisely in transforming the archaic violence of the myth into the beauty of his painting (see Holm-Hadulla, 2011).

Beginning with the earliest cultural artifacts, humans have engaged in communication about themselves and their environment by means of animistic and metaphysical ideas later elaborated in the form of complex myths. Religions and philosophies developed these ideas further, ideas deriving from the natural world

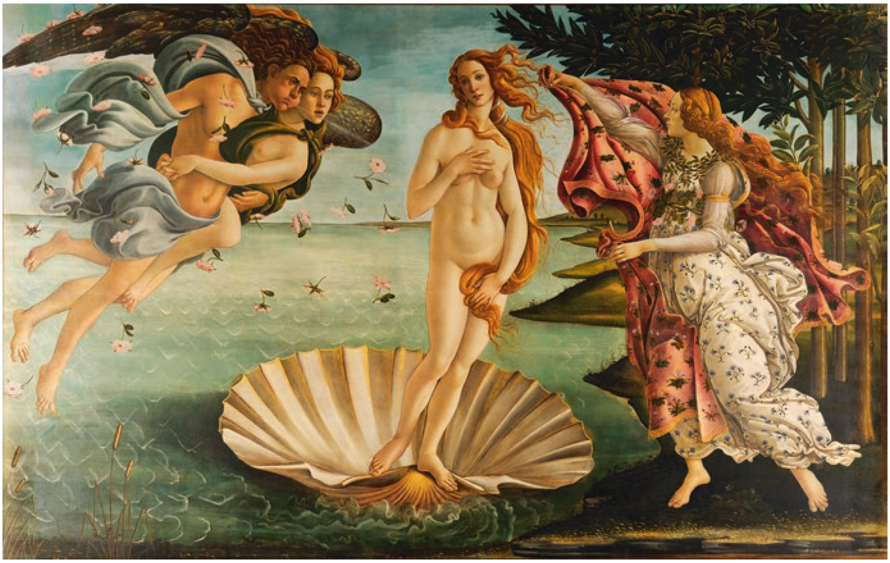

Fig. 1.2 "Birth of Venus" by Sandro Botticelli (created c. 1484–1486). (Source: https://de.wikipedia.org/wiki/Die_Geburt_der_Venus_(Botticelli))

and designed to provide guidance for a good life and for meaningful communal organization. Linguistic and esthetic forms are essential here because they perpetuate the contents of cultural memory in ways completely beyond the reach of the animal kingdom. Not only since the "Axial Age" around 500 BC (Jaspers, 1949), in which new interpretations of man, the world, and personal and political life emerged simultaneously in the most diverse regions of the world, has it been legitimate to speak of specifically human intelligence. The thinkers of the Axial Age—Confucius and Lao-tzu, Gautama Buddha, Zarathustra, the Old Testament prophets, the pre-Socratic philosophers, etc.—show very clearly how far human intelligence had emancipated itself from its natural conditions. With the mediation of thinkers such as Plato and Aristotle, they continue to shape the world of our imagination to this day.

7 Political Intelligence and Wisdom

In fine, the highest form of intelligence is neither technological nor artistic, but ethical and political. This idea can be traced back to ancient Greece and ancient China, e.g., in the writings of Plato, 428/427-348/347 and Confucius, 551-479. The very same idea lies at the root of the democratic discourse ethic (see above; cf. Habermas, 2011).

The psychologist Sternberg argues that meta-theoretically individual forms of intelligence—analytic, fluid, or crystalline—can be incorporated into the value-based concept of "wisdom" (Sternberg, 2003). He suggests that the same "meta-components" underlie these different aspects of intelligence, identifying a problem, defining its nature, formulating strategies for solving it, and so forth. In the field of formal intelligence, these components figure in the acquisition, application, and analysis of knowledge, whereas in creative intelligence they are associated more with finding new and useful ideas. Wisdom, on the other hand, is concerned more with "common goods" (Sternberg, this volume). To better understand the interplay, i.e., the dependencies and independencies of the different levels of intelligence described so far, Sternberg proposes a new construct—that of "meta-intelligence." In so doing, he lays bare the problem that intelligence can be used for (self-)destruction. Accordingly, the factors constitutive for intelligence need to be supplemented by an adaptive intelligence factor—that of wisdom.

Yet it still remains questionable whether the phenomena of intelligence and wisdom can be captured via the methods of empirical psychology. Psychological research is already extended to its limits when it comes to evaluating creative products. It cannot adequately capture such things as the originality and benefit of, say, a mathematical proof, a scientific discovery, a poem, or a song. The psychology of creativity is dependent on evaluation criteria that are drawn from the life-world of the individual or from the various scientific disciplines (cf. Funke, 2009). Even in the case of wisdom, psychology is operating in a realm that cannot be adequately grasped without recourse to historical, philosophical, and political theories on the one hand, and practical and embodied experiences from the life-world on the other. This is why building bridges between these sciences is so essential. Addressing the global challenges we are facing today, such as climate change, water and air pollution, weapons of mass destruction, and the present pandemic, requires an interdisciplinary discourse ethic (Habermas, 2011). This ethic presupposes a form of moral intelligence that is associated more often than not with religious wisdom.

Theologist Oeming makes the case for this view in his article on "*Intelligentia Dei*" (this volume). He argues that many of our modern conceptions of AI and human intelligence are indebted to religious terminology. That implies that these conceptions are embedded in transcendent wisdom deriving from ancient biblical traditions. In the same vein one could also speak of "divine intelligence." This form of intelligence functions in a similar way to one of Kant's regulative ideas in that it confronts human self-overestimation, which is oblivious of its limits, with the ideal of infinity: "It proves to be a necessary corrective against an absurd, totally illusory and self-overestimating belief in technology" (Oeming, this volume).

Religious language also permeates modern natural science. It is, for example, used in the absurd attempts to sacralize AI, as exemplified by the plans to "program God." AI is presented as the business model that will save the world. All this is devoid of wisdom and cultural memory and hence devoid of the essential features that make us human. As a remedy, many intelligent ideas can be found in biblical texts that further our self-understanding and promote meaningful social coexistence. In ancient Greek philosophy, there are noteworthy analogies to biblical texts on the limitations of human knowledge. Oeming (this volume) demonstrates—in Plato's (1985) *Politeia*—how the distinction between appearance and reality is furthered through engagement with mythical ideas. However, the Bible encourages skepticism with regard to the Socratic hope that humankind can be guided to the true, the good, and the beautiful through philosophical education.

On the one hand, the Bible is science-friendly: "Subjugate the earth!" This imperative is readily interpreted as encompassing the exploitation of all the technical resources at our command. But we should be wary of such interpretations. Man must not become a technological Proteus. On the contrary, as humans we must come to terms with our often fractured selves. For Oeming, faith and the critical thinking of the enlightenment belong together. Thus, religious wisdom remains open to technicians and scientists. Albert Einstein expressed this as follows:

"To feel that behind what can be experienced there is hidden something inaccessible to our mind whose beauty and sublimity reach us only mediately and in faint reflection, that is religiosity" (cited after Oeming, this volume). Belief in a form of wisdom that precedes and transcends us is not only religious but also and at the same time philosophical and political.

However, there exists a remarkable contrast between the philosophical idealization of politics and the poor repute in which it stands. One reason for this may be the complexity of political decision-making and the high pace at which opinions have to be formed. In politics, people are constantly "driven by short-term pressure to react immediately and to have a well-founded opinion on everything and everyone" (Bauer, this volume). Politics constantly has to balance different and sometimes conflicting perspectives and interests, organize majorities, and negotiate compromises. Thus, politics is regarded by many as a "dirty business." However, the viability of liberal democracy hinges on the fact that the quest for what is good, true, and beautiful must always stay in touch with the processes of public discourse: "Political intelligence thrives on preconditions that politicians cannot create on their own. It lives from the power of judgment, the sense of responsibility, and the ability of many to face the tasks of the present and the future. Good persuasion, feasible approaches to solutions, persistent securing of majorities and resources is at the core of our business as politicians—and it undoubtedly requires some political intelligence to do so" (Bauer, this volume).

Political intelligence combines both a moral and a practical worldview. As such, it transcends instrumental and operational intelligence and is in some respects closer to wisdom. Harnisch (this volume) illustrates the tension between political intelligence and wisdom by contrasting Aristotle's morality-oriented prudence with Machiavelli's utility-oriented astuteness. Political wisdom is a relational concept that combines cognitive and affective self-orientation processes with the ability to understand others as part of a political community (Harnisch, this volume). Such wisdom must deal with considerable complexity in pluralistic societies and be sufficiently flexible to find adequate solutions for the rival claims of knowledge and interest. In other words, it functions in the same way as Aristotle's *phronesis*, which transcends mere knowing (*episteme*) and doing (*poiesis*).

Thus, it behooves political wisdom to integrate findings from different perspectives, including individual scientific disciplines, within the horizon of the life-world. This function of mediating between the parts and the whole is essential to political wisdom and links it to the tradition of hermeneutic understanding (Gadamer, 2008). It acknowledges that any interpretation will rest on a prior understanding of the phenomena involved and proceeds by breaking down and revising such preconceptions in the light of what is learned in the course of interpretation. This structure is the reason why we speak of a hermeneutic circle. It also encompasses another aspect, namely that scientific knowledge is historically and socially contextualized. In order to understand a given scientific insight, hermeneutical understanding considers aspects such as the discursive structure it is relevant to, the scientific works it builds on, the politics of its time, and so forth. Lastly, hermeneutics is akin to Socratic dialectics in stressing that truth is the result of a shared process of understanding. Hence, hermeneutical understanding entails an interactionalist or dialogical conception of truth. It is hard to explain this interactionalist and communicative dimension of intelligence with the methods of the empirical sciences. Its clearest expression can be found in the socio-political struggle for recognition (Hegel, 1807/2007; Habermas, 2011; Honneth, 2014). In a similar vein, Goethe formulates a relevant imperative at around the same time as the aphorism on nature quoted at the beginning of this article: "Let man be noble, /helpful and kind!/For that alone/distinguishes him/from all other beings/that we know … /For nature/is unfeeling/the sun shines/for evil and good men alike, /and the moon and the stars beam/for the criminal/as for the best of men." (Appelbaum, 1999, p. 73).

Today, we have a more ambivalent attitude to the idea of moral superiority, and we are no longer so quick to place human intelligence above everything else. Nevertheless, nature itself is blind to its destructive forces, so that all hope for a better future resides in humanity. We humans must use our multiple intelligences responsibly, not only for our own benefit but also for the protection of nature as a whole. To this end, the individual scientific disciplines are helpful. But how their findings results and methods can best be communicated on the interdisciplinary plane remains an open question. As far as we know, Hegel was one of the last to try to fit the individual sciences into a hierarchical system (1817/1991). To be relevant for today's sciences, such systems require thorough revision. Nonetheless, in our bid to understand ourselves and the world around us, we are in dire need of the holistic view. Both philosophers like Richard Rorty (2000) and neuroscientists like Singer (1990) emphasize the need for a perpetual effort to create such forms of understanding (see Holm-Hadulla, 2013).

Ultimately, political intelligence and wisdom are necessary to mediate between, and communicate with, the individual scientific disciplines, especially with regard to their real-world applications. Many aspects of science and the life-world demand to be taken into account when dealing with major issues such as climate and peace policy. One topical example of this need for mediation between science and life-world experiences is the ongoing fight against the Covid-19 pandemic. Epidemiologic and virological knowledge alone cannot justify the restrictions on social contacts. Instead, the respective policy-makers must bear in mind a multiplicity of medical