Augmenting Health Economic Evidence Analysis: The Synergistic Role of AI in Deductive, Abductive Reasoning, and Insight Generation

>>> Sharma, S[2]; Singh, G[1]; Pandey, P[2]; Takyar, J[2]; Pandey, R[3]; Bergemann, R[4]
1: Parexel Intl, Mohali, India; 2: Parexel Intl, Chandigarh, India; 3: Parexel Intl, Bengaluru, India; 4: Parexel Intl, Basel, Switzerland

Abstract:

Objective: This review assesses the role of Artificial Intelligence (AI) in health economic evidence analysis (HEEA), with a focus on its comparison with human intelligence (HI). The objective is to evaluate whether AI is merely an assistive tool or if it is revolutionizing HEEA.

Methods: A comprehensive literature review was conducted, encompassing scientific databases such as PubMed and Google Scholar, and philosophical texts, including Aristotelian works. The search focused on articles and material discussing the application of AI in HEEA and its cognitive comparison with HI. The approach involved thematic analysis of the selected literature, emphasizing AI's capabilities, limitations, and its interplay with human reasoning.

Results: In its current state, AI functions predominantly as an assistive tool in evidence analysis, enhancing data processing and preliminary analysis but lacking in autonomous interpretative capabilities. Contrary to some futuristic assertions, there is no substantial evidence supporting AI's revolutionary impact in this domain. AI's limitations are particularly evident in tasks requiring deep contextual understanding, ethical judgment, and complex decision-making – areas where HI excels. The research also highlighted that AI's strength lies in its ability to augment human decision-making, especially in managing large datasets, which complements the more abstract and ethical aspects of human reasoning.

Conclusion: AI's role in HEEA is not a revolutionary force but an augmentative tool to human intelligence. While AI contributes significantly to handling and organizing large volumes of data, the intricate tasks of high-level interpretation, ethical reasoning, and contextual understanding remain the forte of human expertise. The most effective approach in HEEA is a synergistic one, combining AI's computational efficiency with the critical and ethical judgment of human intelligence. This collaboration paves the way for enhanced accuracy and efficiency in evidence analysis, leveraging the strengths of both AI and HI.

Introduction:

In the realm of cognitive processes that propel our understanding forward, deduction and abduction stand as pivotal mechanisms through which humans and machines alike navigate the vast seas of unknowns. Aristotle, the ancient philosopher, laid the groundwork for deductive reasoning. Pierce described this for abduction more that 200 years later in the beginning of the 20th century that proceeds from general premises to specific conclusions and the abductive reasoning that involves starting from an observed outcome to the best explanation. These forms of reasoning have not only survived the test of time but have also found renewed significance in the age of artificial intelligence (AI).

Today, as we stand on the brink of a new era where Generative AI (GAI) and Explainable AI (XAI) promise to expand the horizons of human intellect, the synergy between human and machine intelligence becomes not just a possibility but a necessity. The objective of this exploration is to evaluate the synergistic role that AI and human intelligence (HI) can play in health economics, especially in evidence evaluation, highlighting how this partnership could amplify our cognitive capacities, enabling us to solve complex problems with unprecedented efficiency and creativity.

GAI, with its potential to perform any intellectual task that a human being can, and XAI, which seeks to make AI's decisions understandable to humans, together offer a unique blend of capabilities. This fusion promises to transcend the limitations inherent in each, forging a path toward enhanced problem-solving and innovation. The philosophical underpinnings of deduction and abduction, as articulated by Aristotle, provide a solid foundation for understanding this synergy. By leveraging deductive reasoning, AI can help us draw specific conclusions from general knowledge, automating and refining decision-making processes. Meanwhile, abduction, or the art of hypothesis generation, becomes crucial in the context of AI, where explaining the 'how' and 'why' behind AI-generated solutions is essential for trust and transparency.

As we embark on this journey to dissect the interplay between these philosophical processes and the burgeoning capabilities of AI, it becomes clear that the collaborative effort between human and machine intelligence is not just beneficial but essential. Together, they have the potential to lead to the generation of new insights and solutions, underscoring the timeless relevance of philosophical inquiry into the nature of reasoning and knowledge in the digital age.

Methods:

A comprehensive literature review was conducted, encompassing scientific databases such as PubMed and Google Scholar, and philosophical texts, including Aristotelian works, to collect relevant information related to AI, GAI, XAI, augmented, abduction, deduction, abductive and deductive reasoning in the context of biomedical research, evidence evaluation, and literature research. The search was limited to articles and material published up until the cut-off date of Dec 21, 2023, and an update on March 04, 2024.

The search strategy focused on identifying articles and materials that discuss the application of AI in healthcare, ethical aspects of AI in comparison with human intelligence (HI), and the implications of AI in health economic and evidence analysis. The methodology involved a thematic analysis of the selected literature, emphasizing the capabilities and limitations of AI, as well as its interplay with human reasoning.

The search also aimed to identify relevant literature on augmented reasoning techniques, including abductive and deductive reasoning, and their application in the context of biomedical research and evidence evaluation. The inclusion of these topics provides a comprehensive understanding of the current state of AI in health economic and evidence analysis and its potential to enhance decision-making processes.

No time limits applied for searching backward, allowing for the inclusion of relevant historical literature that informs the current understanding of AI and its comparison to HI in healthcare and evidence appraisal.
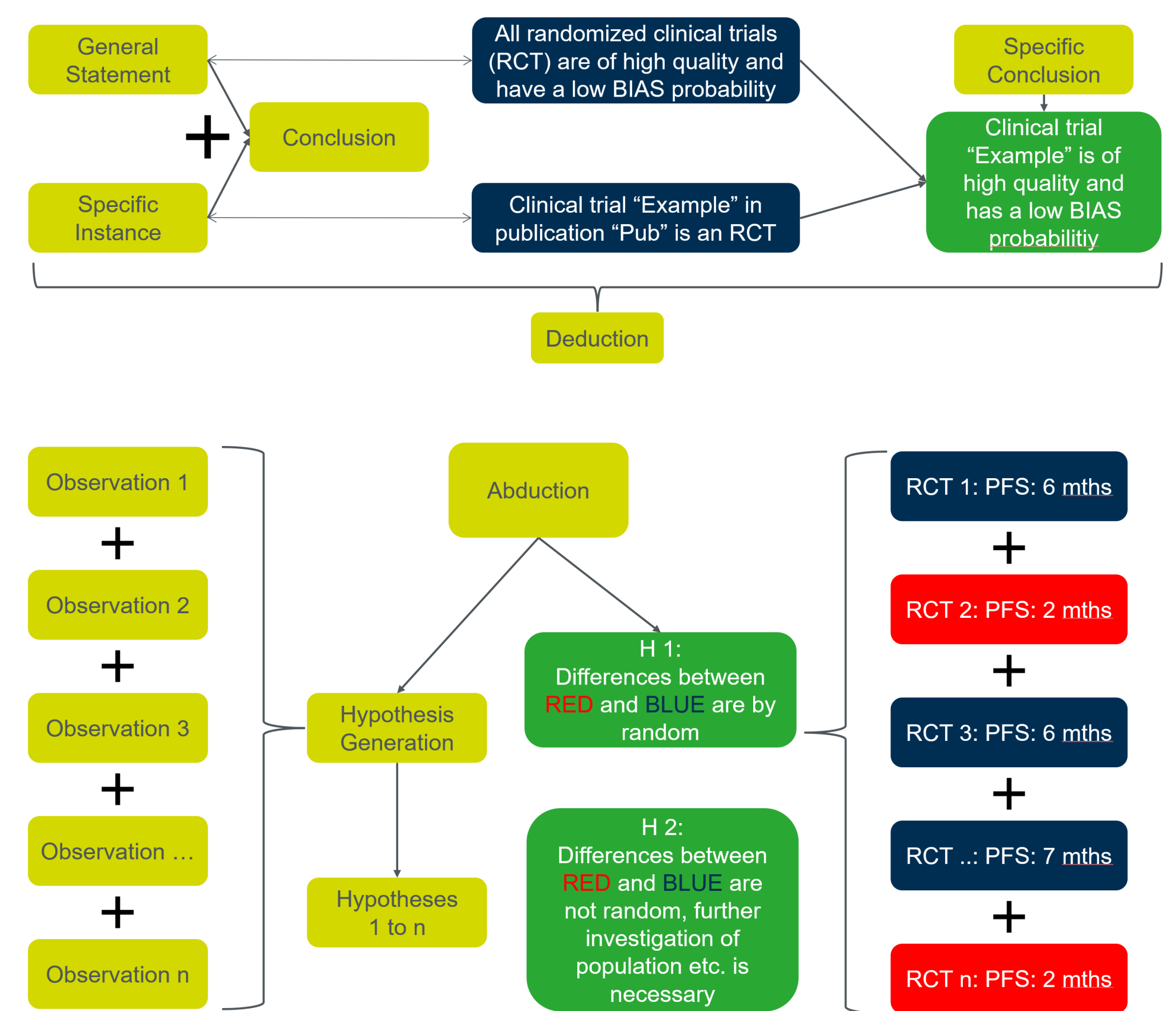

Figure 1: Illustration of deduction and abduction

Figure 2: Even in the 24th century AI is not replacing HI
Data (the Android on the right is supporting the human on the left) has not the "generative" / "creative" intelligence of Jean-Luc Picard, the commander of starship Enterprise
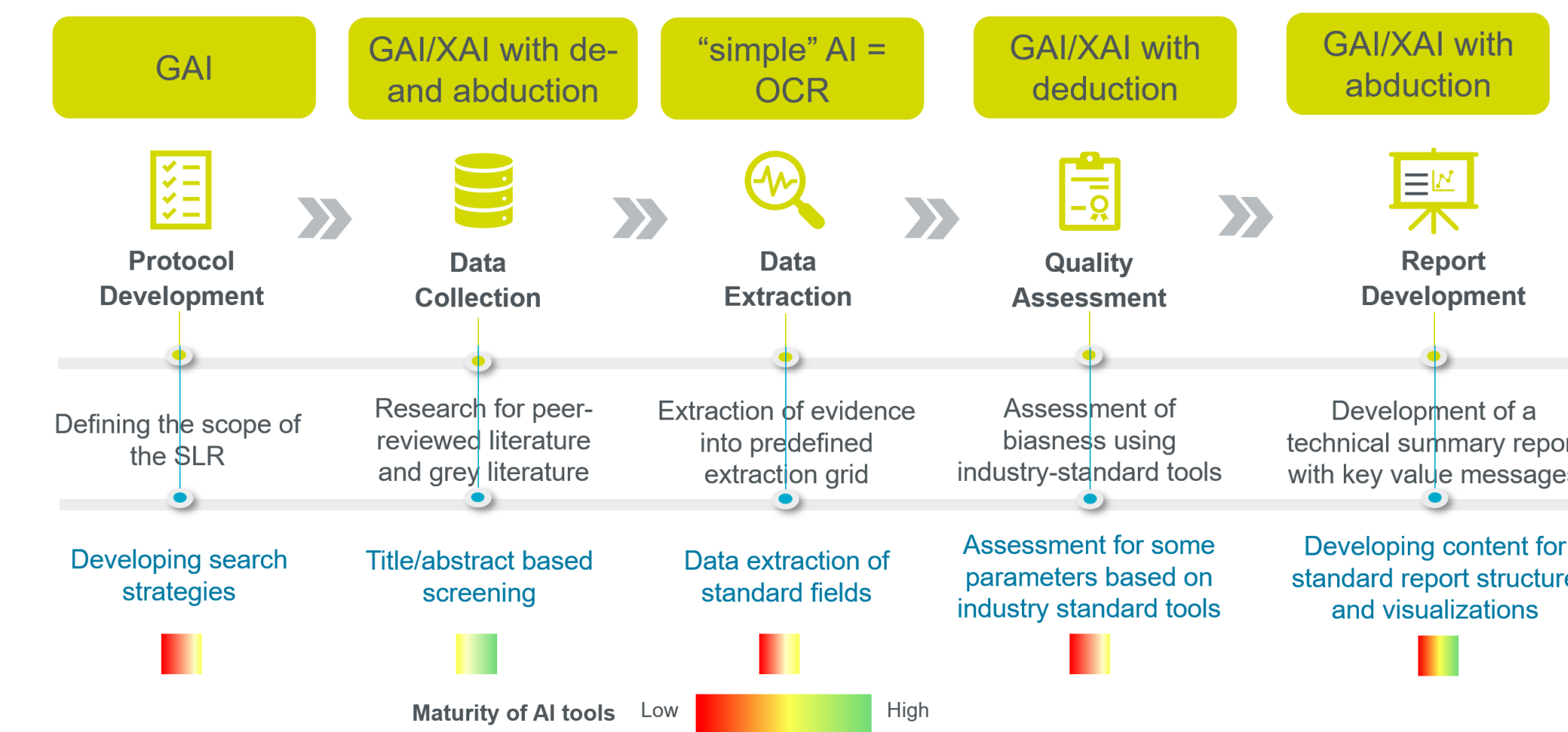

Figure 3: Application of AI / GAI / XAI in various steps during the process of HEEA

Results:

216 publications were identified via the literature research. This initial broad screening resulted in the selection of only two articles deemed pertinent for detailed data extraction regarding the augmentation capabilities of AI in these specific fields. Subsequent reference screening within these two foundational papers identified two additional studies, thereby totaling four key articles that informed the analysis.

The study by Jin et al. (2024) highlights that we are currently in early-stages of AI in augmenting human intelligence within the realms of HEEA and biomedical research. Their findings emphasize AI's current utility primarily as an assistive tool, facilitating enhanced data processing and preliminary analysis and human supervision. However, it also acknowledges AI's significant limitations in autonomous interpretative tasks, particularly those requiring deep contextual understanding, ethical judgment, and complex decision-making.

Further analysis from Jin et al. reveals a nuanced view of AI's application, noting its potential in augmenting human decision-making, especially in the management of large datasets. This capability is suggested to complement the more abstract and ethical dimensions of human reasoning in evidence analysis.

Diaz-Florez et al. (2021) explain the integration of both Large Language Models (LLMs) and Neural Network Language Processing Systems (NNLPS) as a requirement for advancing AI's role in evidence analysis, with a specific emphasis on improving AI's capacity for abductive reasoning beyond traditional deduction and induction methods.

Diaz-Florez et al. (2021) further describe the complexity of AI tools and the necessity for tailored approaches in their development and application. This study underscores the importance of designing AI solutions that are not only technologically advanced but also specifically crafted to meet the unique challenges and needs of HEEA and biomedical research domains.

These findings collectively underline the current state of AI as an early-stage, assistive technology in the context of HEEA and biomedical research, pointing towards its potential for augmentation in human decision-making processes, yet also highlighting the crucial need for further development and customization of AI tools to fully realize this potential.

Conclusion:

The integration of AI into Human Evidence Evaluation and Analysis (HEEA) underscores its role not as a usurper of human intelligence but as an augmentative force, enhancing human capacities while highlighting the irreplaceable value of human insight. This perspective is echoed in the narrative arcs of "Star Trek: The Next Generation," where the interplay between human characters and the android Data exemplifies a future where AI and human intelligence coexist in symbiosis, each complementing the other's strengths.

Drawing from the recent study by Jin et al. (2024), we see a reflection of this symbiotic relationship in the current landscape of AI augmentation. The study underscores AI's significant contributions to managing large datasets, yet it also delineates the technology's limitations in areas requiring high-level interpretation, ethical reasoning, and contextual understanding—domains where human expertise remains paramount. This nuanced understanding of AI's capabilities is crucial for navigating its integration into critical fields like HEEA, emphasizing the technology's role as an assistive tool rather than a replacement for human cognition.

The cautionary tale of IBM's Dr. Watson (Bennett 2018) further illustrates the importance of a balanced integration of AI, showcasing the potential pitfalls of overreliance on artificial systems without adequate human oversight. Watson's failure in healthcare diagnostics and treatment recommendations highlights the need for validating AI tools, ensuring they are leveraged in ways that enhance human decision-making rather than undermining it.

Incorporating these insights into a conclusion that also draws from the rich narrative of "Star Trek: The Next Generation," we envision a future where AI serves as a powerful ally to human intelligence. In this future, AI's computational efficiency and data processing capabilities are paired with the critical thinking, ethical judgment, and creative problem-solving abilities of humans. This partnership not only maximizes the strengths of both AI and human intelligence but also addresses the limitations of relying solely on artificial systems for tasks that require the nuanced understanding and ethical discernment intrinsic to human cognition.

In summary, the effective integration of AI into HEEA and beyond mirrors the collaborative dynamics between humans and AI as portrayed in "Star Trek: The Next Generation." It embodies a future where technology augments human potential, enhancing our ability to process and analyze information while preserving the critical and ethical frameworks that define our humanity. This balanced approach paves the way for a more accurate, efficient, and ethically sound application of AI, where the goal is not to replace human expertise but to augment it, ensuring that the final judgment and creative leaps remain distinctly human endeavors.

References:

Aristotle: (~350 BC) Categories. On Interpretation Prior Analytics, 1938 Translated by H.P. Cooke and Hugh Tredennick, Harvard University Press

Peirce, C. S. (1901). "On the Logic of Drawing History from Ancient Documents Especially from Testimonies." The Monist, 11(1), 27-58.

Philosophisches Wörterbuch, Hrsg G Klaus and M Buhr, Verlag das Europ. Buch, Berlin, 1987

Jin,Q; Leaman; R; Lu Z; PubMe and beyond: biomedical literature search in the age of artificial intelligence; eBioMedicine (The Lancet Discovery Science) Volume 100, 2024; DOI:https://doi.org/10.1016/j.ebiom.2024.104988

Diaz-Flores, E., Meyer, T., Giorkallos, A. (2022). Evolution of Artificial Intelligence-Powered Technologies in Biomedical Research and Healthcare. In: Beutel, S., Lenk, F. (eds) Smart Biolabs of the Future. Advances in Biochemical Engineering/Biotechnology, vol 182. Springer, Cham. DOI:https://doi.org/10.1007/10_2021_189

Bennett C (2018) Watson recommends incorrect cancer treatments, system training questioned. Clin Omics 5:29–29. https://doi.org/10.1089/clinomi.05.05.17

Mellin WD (1957) Work with new electronic "brains" opens field for army math experts. The Hammond Times, p 65

www.parexel.com