A STUDY OF HOLISTIC ARTIFICIAL INTELLIGENCE (HAI) AND GAPS IN THE CONCEPT

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ABSTRACT

Customer experience is a competitive driver of growth. By 2025, 95% of all customer interactions will use artificial intelligence (AI) technology-supported channels. The pathway to customer-centricity goes through conversational AI (CAI). CAI encompasses more and more artificial emotional intelligence (AEI) development. Machine learning, natural-language understanding, and processing help analyze customer emotions and feedback to improve customer experience. However, even holistic AI (HAI) definitions rarely encompass the AEI dimension in the fast-changing world of AI technologies. This situation hampers the standardization of natural-language understanding and processing in CAI and, therefore, the creation of emotional and ethical machines.

The present study systematically explores the available AEI definitions, compares the mobilized defining attributes, and determines the core and peripheral assumptions of the AEI research to overcome this lack of AEI integration. Beginning with a review of the literature, the resulting resources are semantically analyzed to identify the specific elements included in each author's definition of artificial intelligence. This provides a framework to enable cross-comparison of the definitions in a consistent manner.

Keywords: Artificial Intelligence, AI, Emotional Artificial Intelligence, EAI, Holistic Artificial Intelligence, HAI.

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Jamie Lynn Brennan

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CHAPTER 1
INTRODUCTION

The concept of Artificial intelligence emerged first with Gödel (1931) when he asserted that logic can be used to prove that semantic truth can be proved syntactically. This insight lead to his compactness theorem, asserting that if a formula is a logical consequence of a potentially infinite set, then it is a logical consequence of a finite set. The idea that consequential relationships can be logically derived is at the heart of the aspiration of artificial intelligence and machine learning. When logic can be derived, accurate models can be created and ultimately, understanding achieve. Turing (1950) built on this seminal work during 1937-1950 and pointed out the limitations of AI by creating the Turing Test to determine if a created system can be considered intelligent. From these early applications, the rise of modern AI will follow the development of computer hardware and software technology (Ertel, 2017).

Today AI is part of most industries and institutions (Dharinya & Ephzibah, 2020). AI is leveraged to automate business processes (Senderovich, Di Francescomarino, & Maggi, 2019), eliminate inefficiency (Sozontov, Ivanova, & Gibadullin., 2019), and improve customer experience (Schreuder, Schreuder, & Van Wyk, 2017). AI's main applications across significant industries include healthcare, retail and e-commerce, food technology, banking and financial services, travel, manufacturing, real estate, logistics, transportation, and entertainment (Takyar, n.d.). Despite these numerous applications and the profound interest of academics, practitioners, and policymakers, only a single agreed-upon, solid conceptual AI definition exists (European Commission., 2018). AI has a wide variety of defining attributes, ranging from machines that have human behavior to machines that are capable of activities that require actual and complex intelligence (Albus, 1991; Bellman, 1978; Fogel, 1995; Gardner, 1983, 1987; Luger & Stubblefield, 1993; McCarthy, 1988, 2007; McCarthy, Minsky, 1969; Minsky, Rochester, & Shannon, 1955; Newell & Simon, 1976; Nilsson, 1998; Russell & Norvig, 1995; Winston, 1992). The consensus definition of AI uses human intelligence as a reference. However, human intelligence remains ill-defined despite all attempts to qualify it clearly (Gardner, 1983, 1987; Neisser, et al., 1996). At least eight types of intelligence

have been identified as components of Human intelligence: 1) linguistic 2) Logico-mathematic 3) bodily-kinesthetic 4) spatial 5) musical 6) Interpersonal 7) intrapersonal (Gardner, 1983), and 8 emotional (Goleman, 1996). The willingness of some scholars, especially in the medical field, to encompass as many types of intelligence as possible in the AI definition led to four main categories of AI: Reactive Machines AI, Limited Memory AI, Theory of Mind AI, and Self-Aware AI. This analysis will examine the need for Holistic Artificial Intelligence (HAI) as fitting within the definition of Theory of Mind AI (Cuzzolin, Morelli, Cîrstea, & Sahakian, 2020).

1.1 Rationale and Problem Statement

In the fast-changing world of AI technologies, analogues of emotional intelligence are rarely included. Because it is abstract, subjective, and complex, a clear definition of the concept emotional intelligence in the field of AI still needs to be established (Kaplan, 2016). Picard (1997) suggests that if the decision-making of emotionally intelligent agents were incorporated into computers (AI), it would yield an intelligent solution to emulating the intelligence of humans. Potentially even more compelling where decisions with insufficient data and slow processing speeds are present. This affirms the value of incorporating emotional decision-making into the concept and practice of AI. The capacity of the human mind to attribute mental states to external beings, is a key component of sapience. The artificial intelligence need not experience emotions itself, but in order for it to have an accurate awareness of the existence of other minds, it must understand that emotions are an indelible attribute of the other minds it interacts with. This is a key distinction between artificial intelligence which is aware of its own existence, and a sapient intelligence which is aware of and understands the minds of other beings. Practitioners will need to broaden the scope of their work to include psychiatrists, psychologists and neuroscientists. New models will need to be developed, in order to accurate frame the problem and determine if the results are successful. This analysis will attempt to answer the core question of how to define Holistic Artificial Intelligence so researchers, practitioners and users can move towards an empathetic AI system that supports humanity and understands the impacts of decisions and outcomes.

1.2 The Objective of the Research

The question of this paper is what is the concept of Artificial Intelligence as Holistic Artificial Intelligence? There are many definitions from the start of AI, but what is the actual definitive concept of Holistic Artificial Intelligence? Starting in 2017, some definitions of artificial intelligence included the perception of the environment and adaptation to it, as seen in Statista (2017 cited in European Union, 2020) and Tsinghua University (2018), and others referenced in the definition review table (Appendix B). While these definitions do not specifically mention the use of emotions, flexibility, and adaptation aligns with the definitions of human emotional intelligence. Moreover, if we indeed follow the dominant component of the concept of AI, as shown in this example from the OECD in 2017, "Artificial Intelligence (AI) is a term used to describe machines performing human-like cognitive functions (e.g., learning, understanding, reasoning or interacting)." Then it is clear that, while the concept of holistic artificial intelligence is not yet complete, it is moving toward understanding complete human intelligence represented in AI systems.

This paper endeavors to demonstrate what path will be needed to establish a testable definition of artificial emotional intelligence, in order to establish whether a given AI implementation can be considered holistic. Absent an integrated conceptualization of emotional intelligence, the current trajectory will be unable to achieve rationality as defined by the High-Level Expert Group on Artificial Intelligence (High-Level Expert Group on Artificial Intelligence, 2019) as "A system is rational if it does the "right thing," given what it knows" (Russell & Norvig, 1995; 2010). It may also be noted that this conceptual definition following Gerring's (1999) framework, attempting to build on the perceived oversimplification of intelligence as a concept shown in Russell and Norvig (1995, 2010).

Within the broadly defined and rapidly changing world of artificial intelligence applications, specific applications such as Conversational AI provide better customer experience when the user perceives empathy and contextual response. Therefore, in order to focus future development in this application of AI, a framework for understanding how to define emotional intelligence within the realm of Conversational AI is necessary. This research aims to develop definition for holistic

artificial intelligence using the framework of derived from Theory of Mind and further elaborated in section 1.5.

1.3 Main (RQ) and Sub-Research Questions (SQ_i)

RQ**:** How can emotional intelligence enhance the usefulness of artificial intelligence applications which focus on customer interactions?

SQ_1**:** What definition attributes of emotional intelligence is most appropriate for this type of application?

SQ_2**:** How does the field of artificial intelligence research integrate the concepts of emotional intelligence?

1.4 Significance of the Research

The development of artificial intelligence is reaching increasing sophistication and adoption. Both in scientific applications, such as protein folding, and user-level interaction such as ChatGPT (Fernandez, 2020), the industry is approaching consumer level applications of AI which demonstrate increasing sophistication in Theory of Mind. Accordingly, the distinguishing characteristics of this type of AI are central to the successful development of conversational AI tools, and the deployment of these tools by users.

1.4.1 Academic Implication

Without an agreement on the available definitions, research and applications exploiting the definitions of emotional intelligence progresses haphazardly and without ethical standards. Moreover, optimization and standardization of NLP would increase AI's ability to develop, through deep learning, the needed empathy and emotional intelligence ensuring commercial applications which include moral reasoning (Bostrom & Yudkowsky, 2014).

Additionally, clear concepts allow further testing and training of viable artificial intelligence in the future as the concepts can be more readily applied to complex activities and increase the ability for oversite as the concepts can be used to build a framework for review.

1.4.2 Practical Implication

AI developers will benefit from utilization of AEI conceptualization, as it will provide an organized definition to evaluate and optimize current and future implementations, thereby enabling the development of new technological approaches which can deliver superior results For example, chatbot emotional intelligence improvement, would allow the optimization of customer emotional attachment. To achieve such a goal, trust and a greater perceived positive value are key parameters (Herscovitch & Meyer, 2002). Trust lower transaction costs and promotes long-term customer relationships and customer satisfaction (Freire, 2000). Through the increase of trust, customer commitment can lead to loyalty and to the co-creation of value (Bricci, Fragata, & Antunes (2016) and therefore, to greater customer-centricity.

1.5 Definition of Terms

Reactive Artificial Intelligence (AI): This type of artificial intelligence is considered the most rudimentary. It is commonly seen in applications such as games, including chess and Go. These applications respond to the same stimulus in the same way repeatedly, and do not adjust their approaches (Marr, 2024).

Limited Memory AI: This implementation of artificial intelligence demonstrates a capacity to adjust to incoming information and change approaches as needed. A basic version of these types of applications can be seen in search engines which dynamically re-prioritize results based on the selections of users (Chung, Le, Thaichon, & Quach, 2022).

Theory of Mind AI: This form of artificial intelligence encompasses decision-making capabilities similar to people. It includes the capacity for understanding and remembering emotions, and to alter behavior based on the interaction of the emotions of the users (Pauketat, 2021).

Artificial Emotional Intelligence (AEI): AEI refers specifically to the emotional capacities within the definition of Theory of Mind AI (Kumar & Singla, 2015).

Conversational Artificial Intelligence (CAI): Conversational AI is a specific type of application of artificial intelligence tools. More basic versions might only demonstrate Limited Memory or Reactive levels of sophistication. This paper focuses

on the usefulness of Theory of Mind to the specific application of Conversations AI modalities (Song & Xiong, 2021)

Self-aware AI: This advanced form of artificial intelligence is currently outside the capacities of existing systems and this paper. These types of applications would be aware of their own existence and the existence of others (Kelley, 2019). Complex inferences including cause and effect relationships integrating the agency other minds is a unique element of this definition,

Sentience: A being which demonstrates a conscious sense of self, even with very little cognition (Yolles, 2022).

Sapience: A consciousness which demonstrates a human level capacity to learn, reason, discern the independent existence of other conscious minds and acquire wisdom. An example of this distinction can be seen in the levels of communication demonstrated by primate cognition (Yolles, 2022). In this rubric, ideas and abstract references are utilized. However, all of the current literature in this field indicates these exchanges notably lack examples of primates initiating questions to humans. Current understanding theorizes that this is because the primates are not able to conceptualize the independent consciousness of the human with whom they are interacting. Therefore, due to this lack of understanding, they are unable to conceptualize that the individual human may know something which they themselves do not. Under these definitions, a primate would be considered sentient, but not sapient. The terms ‘sapience’ and ‘human intelligence’ will be used interchangeably in this text (Premack & Woodruff, 1978).

CHAPTER 2
LITERATURE REVIEW

This chapter provides theoretical support for the concepts used in this thesis. The chapter intends to establish research gaps and problems with existing knowledge to determine what the research could most usefully address. The first part of this chapter provides an analysis of the components associated with the history of Air. Following this, section 2.2 addresses the current conceptual framing of AI. The last section (2.3) examines the role of Holistic Artificial Intelligence.

The literature review shows us that there are few accurate definitions of concepts for HAI. As such, the research of others was built upon to find an extensive list of definitions and literature reviews to reduce research redundancy.

Before delving into the details of the definitions and concepts of Artificial Intelligence and its evolution to Holistic Artificial Intelligence, the paper will first review the eight types of intelligence that have been described for humans thus far, as detailed in Section 2.1.2:

AI has already been mobilized successfully to improve customer-centricity efficiency (Chan-Olmsted, 2019; Gacanin & Wagner, 2019) mainly by business ecosystems (Gupta, Mejia, & Kajikawa, 2019; Hacioglu, 2020; Quan & Sanderson, 2018). Customer experience is a significant competitive driver of corporate growth. Therefore, it is unsurprising that communication with customers supported by artificial intelligence technology is estimated to represent 95% of all customer interactions by 2025 (Kaplan & Haenlein, 2020). The pathway to customer centricity goes through conversational AI – CAI (Gentsch, 2019).

CAI encompasses more artificial emotional intelligence (AEI) development (Aga, 2019; Catania, Crovari, Spitale, & Garzotto, 2019). Machine learning, natural-language understanding, and processing help analyze customer emotions and feedback to improve customer experience (Lam, et al., 2019). Because all of these technologies rely on deriving statistical relationships between elements of a dataset without understand the actual content, these approaches are far from demonstrating awareness of self or others. That being said, some language models in very limited subject domains can produce near human results. One such example is the product

known as ChatGPT3. In order to address this gap of understanding, closer integration with human psychology can be helpful.

Emotional Intelligence was first popularized in study of human psychology in the late 1980s; however, predecessors existed, like Thorndike (1920)'s concept of social intelligence from the 1920s (Thorndike, 1920). A person's social intelligence is often linked to their "ability to understand and manage other people, and to engage in adaptive social interactions" (Kihlstrom & Cantor, 2000); emotional intelligence deals specifically with one's ability to perceive, understand, manage, and express emotion within oneself and in dealing with others (Salovey & Mayer, 1990). Salovey and Mayer (1990) define five domains critical to emotional intelligence: knowing one's emotions, managing emotions, motivating oneself, recognizing emotions in others, and handling relationships. This situation hampers the standardization of natural language understanding and processing in CAI and, therefore, the creation of emotional and ethical machines.

2.1 Artificial Intelligence

2.1.1 History of AI Development

1931 The Austrian Kurt Gödel shows that in first-order predicate logic, all factual statements are derivable (Gödel, 1931). In higher-order logic, on the other hand, there are unprovable factual statements (Gödel, 1931). In Gödel (1931), the author shows that predicate logic extended with the axioms of arithmetic is incomplete.

Industries have engaged in a variety of AI activities (Chitturu, Lin, Sneader, Tonby, & Woetzle, 2017), "Machine learning innovations can enhance credit models and financial inclusion […]. AI solutions can enable new types of preventive and remote health care; they may also improve diagnoses and speed the development of new drugs. Adaptive learning algorithms could play a role in delivering individualized and virtual education". According to Ramos, Augusto and Shapiro (2008), Industries are moving quickly. Even with the auspicious goals of health and education, the quality and ethical level of AI interactions with humans requires the development of AEI (Bostrom & Yudkowsky, 2014). Further detail on this point is included in appendix A.

2.1.2 Human Intelligence Defined

Since its emergence (McCarthy, et al., 1955), the concept of AI has been connected to the definition of Human intelligence (sapience), as distinct from the more general definition, seen in the specific identification of consciousness (sentience). Six main domains of sapience are recurrent in AI definitions (Sadovsky, 1996):

1) Functioning of natural intelligence
2) Development and implementation of intelligent computer programs
3) Natural intelligence theory
4) Intelligent programming theory
5) Systems-cybernetic paradigm
6) Philosophy, methodology, and logic of knowledge, primarily scientific knowledge.

Sapient human intelligence remains the most prominent domain of reference to define AI. Within this scope, eight elements of intelligence are commonly conceptualized:

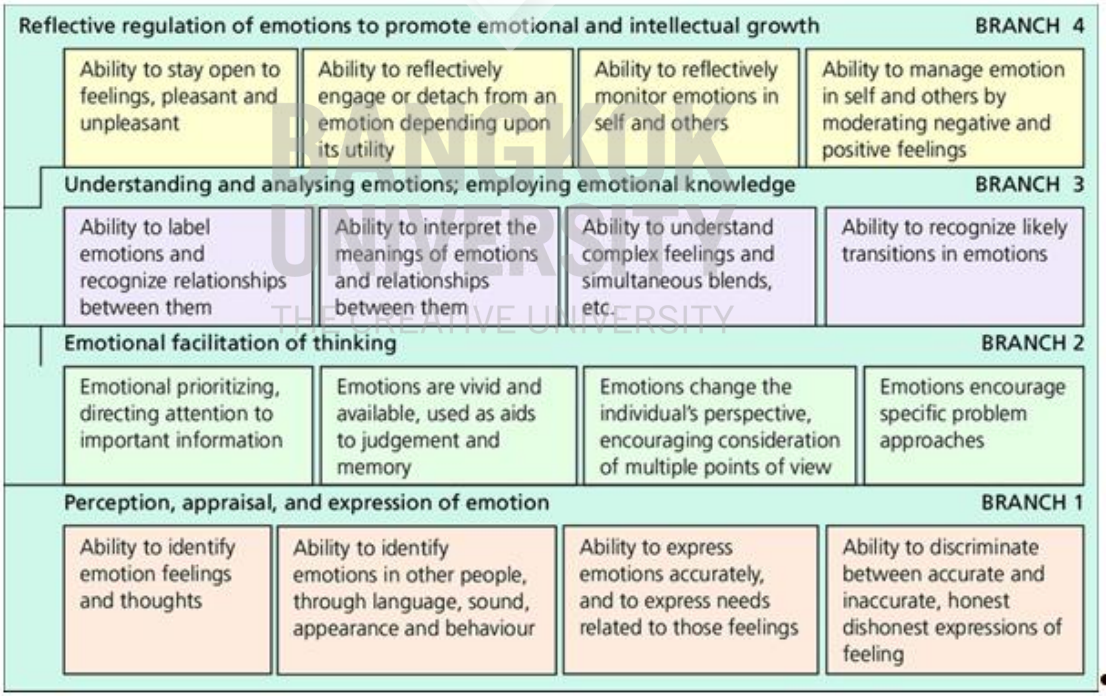
1) Linguistic: definition (Gardner, 1983)
2) Logical-Mathematical: seminal definition (Gardner, 1983)
3) Bodily-kinesthetic: seminal definition (Gardner, 1983)
4) Spatial: seminal definition (Gardner, 1983)
5) Musical: seminal definition (Gardner, 1983)
6) Interpersonal: seminal definition (Gardner, 1983)
7) Intrapersonal: seminal definition (Gardner, 1983)
8) Emotional: seminal definition (Goleman, 1996)

As the understanding of human psychology and psychometrics continues to develop, these categorizations are regularly updated and refined. Therefore, the continuing progression in understanding human cognition, together with rapidly evolving technological applications, presents conceptual challenges in analytical work of this type (Atreides, Kelley, & Masi, 2021). Moreover, most definitions ignore the categories of intelligence identified in Human intelligence and speak about Human intelligence as if it was a clear referent to everyone. In addition, the emotional dimension of Human intelligence is, most of the time, skipped.

2.1.3 Development of EI over time

Many authors have researched this subject, but the most seen is when comparing the intelligence research of Salovey and Mayer (1990) who, at that time, defined Emotional Intelligence (EI) as a kind of intelligence consisting of a set of 16-20 abilities grouped in 4 general groups labeled as I) perceiving emotions; II) integrating emotions in the facilitation of thoughts; III) understanding emotions; IV) regulating emotions (Figure 2.1) and the potential future of robotics/AI. "Emotions are physical experiences universal to all humans and many other animals. Robots are expected to become capable of perceiving others' emotions, develop their emotional state and manifest it".

Figure 2.1: Components of Emotional Intelligence



Source: Mckenna, J. (2007). Emotional intelligence training in adjustment to physical disability and illness. *International Journal of Therapy and Rehabilitation, 14*(12), 551-556.

There are also widely accepted measures of human intelligence, including emotional intelligence, that Dodds, Alvarado and Sood (2008) noted to have expanded Salovey and Mayer (1990) define five domains critical to emotional intelligence: knowing one's emotions, managing emotions, motivating oneself, recognizing emotions in others, and handling relationships. A common measure of Emotional Intelligence is EQ (emotional intelligence quotient), as gauged by many widely published EQ tests."

2.2 The Concept of AI

The AI concept constantly revolves around the evolving definitions of sapience and conceptualizations of different forms of sapient intelligence. With each new technological disruption, analytical frameworks must be updated (Jiang, Li, Luo, Yin, & Kaynak, 2022). Thus, depending on the perspective applied to characterize AI: a set of technical functionalities or comparison to human thinking and behavior, defining attributes mobilized vary. However, definitions encompassing AI systems functionalities are more inclusive of technologies in use today, whereas definitions emphasizing human-like capabilities are most applicable to hypothetical future technologies (Krafft, Young, Katell, Huang, & Bugingo, 2020). In such a context, even the most robust definitions often lack the inclusion of emotional intelligence, which is required to ensure AI ethical behavior and economic viability in a customer-centric era (Latinovic & Chatterjee, 2019). Moreover, the breadth and diversity of AI applications complexify establishing an AI consensual definition and lead to great debates (Redman & Luo, 2019; Welsh, 2019).

If AI applications' economic viability has been demonstrated in some cases (Gil, Hobson, Mojsilović, Puri, & Smith, 2020; Girasa, 2020), designing ethical AI remains challenging. Reactive AI collects knowledge from epistemic information (i.e., facts that help us to evaluate the credibility or reliability of a piece of information or a source), and then operates based on these facts. However, since 'one cannot derive values from facts' (Hume's Guillotine), reactive AI therefore will be unable to develop values and ethics. Saariluoma and Rousi (2020) distinguish weak AI systems (Limited Memory AI) operating only within given value rules from Reactive AI systems that may generate new values. The next step in such systems

would reach the awareness of the existence of one's own mind (consciousness) leading to the understanding of the existence and nature of other minds (sapience). However, they doubt that robust AI systems are available among the existing applications. The challenges Google encountered during its AI development illustrate the difficulties of ensuring virtue in AI design (Neubert & Montañez, 2020). To overcome this issue, Samsonovich (2020) proposes extending the general framework of emotional Biologically Inspired Cognitive Architecture (Samsonovich, 2013, 2018a, 2018b), to integrate, moral and ethical values. This model also includes self-organization of semantic maps that guide active humanlike learning. At current levels of sophistication, this is an example of modeling advanced concepts within a reactive AI system. It may appear to behave in a similar way to a sapient being, but it lacks the understanding of the existence and nature other minds, indicating that is remains unlikely to pass the Turing test.

Natural language processing (NLP) using semantic maps is at the core of emotion recognition and processing. Recent progress in NLP has increased the quality of natural dialogues and interactive storytelling with AI, especially in the video game industry (Yannakakis & Togelius, 2018), health care (Oh, Lee, Koho-Jin, & Ho-Jin, 2017; Yu, Beam, & Kohane, 2018), education (Qaffas, 2019), human resource management (Krithika, Venkatraman, & Sindhujaa, 2019), and marketing (Malpani & Nisha, 2020). Conversational agents, also called chatbots, are AIs that present the most advanced NLP technology. These systems generally operate by separating words into tokens and mapping the statistical probability that certain tokens appear together. For example, such a system would determine that 'grief' often follows 'death' but would have no understanding of the meaning of those words, or the existence of the minds perceiving those concepts. It would however, likely be able to write a passable poem about the grieving process following the death of a child.

In such manners, chatbots can interpret human language during a conversation with a human in text or voice format (Shawar & Atwell, 2007) through social media or dedicated mobile applications. However, they are unable to respond in a human-like way because they lack the sapience necessary to understand the meaning of the emotion, beyond the statistical relationship between the tokens (words). They provide information and help a targeted audience without human operators (Zumstein &

Hundertmark, 2017). Mainly, customers express two types of requests: emotional and informational requests. The application of 3 measurement evaluations (appropriateness, empathy, and helpfulness) to assess response quality for a chatbot in customer service has demonstrated no statistically significant difference between deep learning on chatbots compared to human agents on empathy for emotional requests (Xu, Liu, Guo, Sinha, & Akkiraju, 2017).

2.3 The Concept of Holistic Artificial Intelligence (HAI)

Holistic artificial intelligence, which demonstrates the elements of sapience, is the attempt by academia, practitioners, and policymakers to unify the concept of emotional intelligence and artificial intelligence, therefore accommodating the totality of the potential for Artificial Intelligence which is aware of the existence of itself, of other minds, and that those minds experience emotions. The first references found for HAI were in 1992 by Müller, who referenced the concept of "modularity vs. holism" and what limits that could impose on AI. This definition, like others to follow from 1992 until 2020, focused on holistic artificial intelligence as an integrated view of the theory of mind. However, none of these definitions showed a concept of a conscious holistic intelligence but proposed limited holistic machine models for software connectivity or hardware (Dahl, 2002; Thórisson, 2007). In 2021, in Approaching Artificial Consciousness via Scheler's Framework: Considering the Possibility for Geist in Machines, Boyle (2021) began to explore what incorporating more of the human experience into Artificial Intelligence could mean for creating Holistic Artificial Intelligence. However, Boyle (2021) focuses on the ability of a machine to reach consciousness, which is not the focus of this paper.

Other references to Holistic Artificial Intelligence note the necessity of this concept of emotion in the ability of machines with AI, such as the recommendations for further work on "developing intelligent behavior on robots, in what we call a holistic approach to Artificial Intelligence" (Dahl, 2002).

The literature review yielded 32 articles that were tagged as "holistic artificial intelligence" or had definitions of work that are similar. Of those 32 articles, 29 were removed from consideration. One was the author's work, 1 was a CV, seven were related to the holistic approach to breast cancer detection, and the remainder was

removed due to the HAI being viewed as a distributed network vs. a holistic network, not as related to the holistic approach to intelligence.

CHAPTER 3
RESEARCH DESIGN AND METHODOLOGY

The ontological analysis of the AI and AEI/HAI core defining attributes has yet to be achieved, and the concept remains unclear. Several sources of confusion add up in the formation of the concept, such as the diversity of the criteria and defining attributes chosen to define AI within each perspective leads to different applications of AI in an organization.

The 45 definitions of the European Union (Samoili, et al., 2020) based on a systematic literature review are selected and supplemented by a further 4 definitions through the expansion of the time range of the review from 1920 to 2020. After a review of the definitions, duplicates are removed, and the key attributes are identified and categorized (Samoili, et al., 2020). Those with similar terms or new terms that cover a similar meaning are combined, and the frequency is calculated. Based on this calculation, the defining attributes (DA) are therefore categorized based on their frequency of occurrence into three groups:

1) The core DA (most frequent)
2) The peripheral DA (average frequency)
3) The outsiders (low frequency)

The infrequently occurring, outsider-defining attributes of similar approaches are grouped. The core and peripheral defining attributes are used to identify the most comprehensive definitions. Following this analysis a total of 49 definitions were identified.

This paper proposes as pathway to move past the confusion of the concepts and definitions to create a formal definition and show the analysis of essential, but not all, definitions from the literature. This will support creating a common ontology and evaluate the potential value of the concepts of AI, AEI, and HAI using the framework developed by Gerring (1999). Gerring (1999) proposes valid concepts should include the following considerations:

1) Depth
2) Theoretical Utility
3) Parsimony

4) Coherence

5) Differentiation

6) Resonance

7) Familiarity

8) Field Utility

To achieve this, the methodology described below has been applied.

1) Selection of 49 AI definitions from 60 papers

2) Identification and categorization of the defining attributes from these definitions

3) The frequency calculation of attributes

4) Determinization of the most agreed upon and accurate definition for the concept of Holistic Artificial Intelligence

5) Concept goodness analysis Solthong and Parisot (2020) of the best definition by grading the eight parameters of Gerring (1999) using a 5-point Likert scale.

3.1 Keywords Combination Refinement

Searching sources such as Proquest, Elsevier. PubMed, IEEE Xplore, ScienceDirect and non-academic databases, several keywords were used and refined in combinations that ultimately led to the articles used in this research.

With the largest number of resources being identified in the domain of Artificial Intelligence, a lack of integration of Emotional Intelligence was identified, this research therefore pursued refinement through additional keywords. Specifically, the exploration of Holistic Artificial Intelligence (which is rarely used), Affective Computing (which is broadly focused on), and General Artificial Intelligence (which encompasses more variance and inclusive attributes).

Finally, eight keyword combinations were used, with the combination of “emotional intelligence” + “general artificial intelligence” producing the most accurate results. The total keyword list table is below.

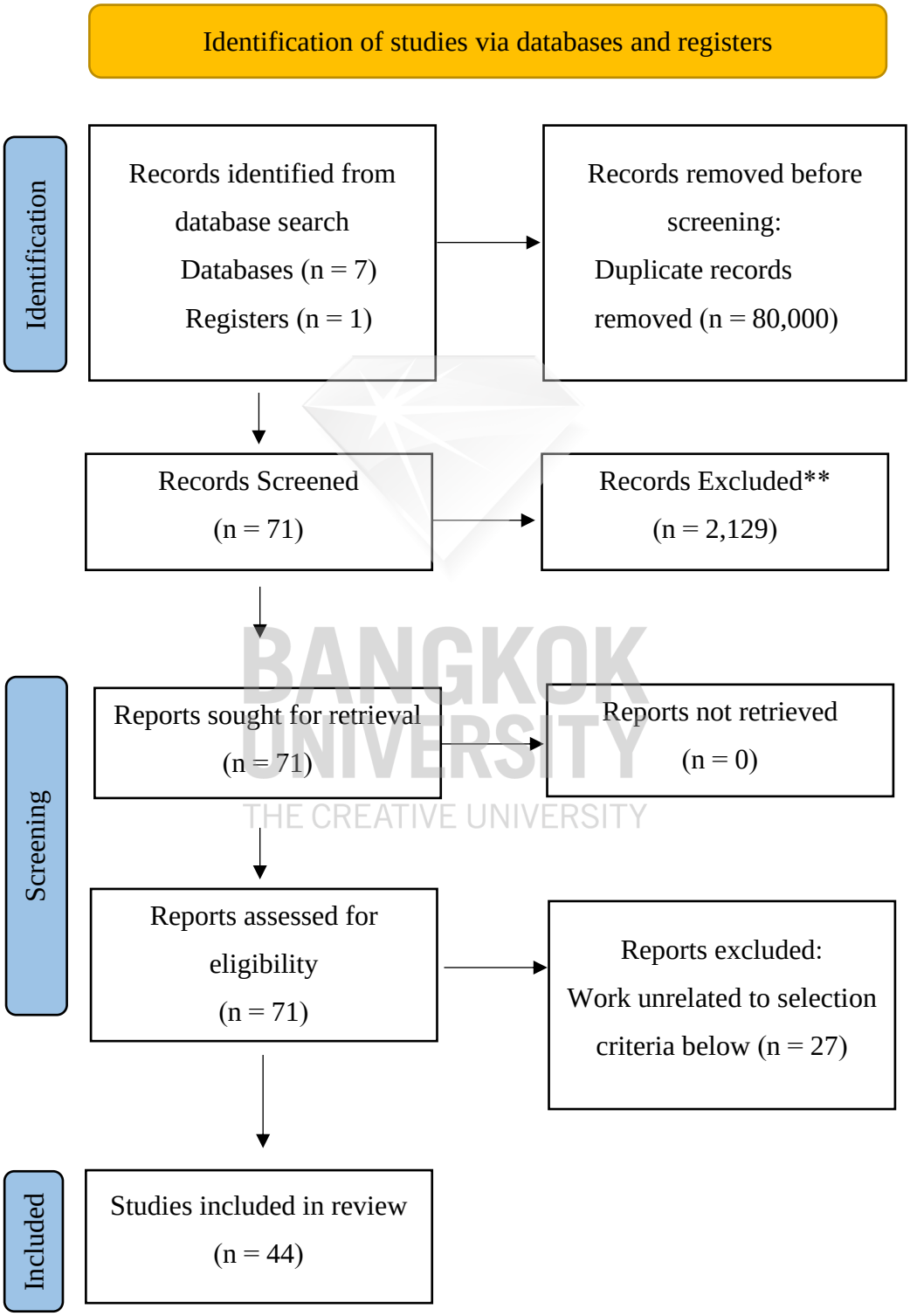
3.2 Systematic Literature Review (SLR)

Utilizing various search engines proved problematic in including many articles, books, and papers that needed to be academic and included false, misleading, or unproven terms.

In addition to the sources detailed in section 3.1, Google, Google Scholar, and EBSCO were used to conduct searches. After review, general Google was removed; though it provided excellent context for the general public's understanding of EAI, it was primarily fictional and of little use.

Focusing on Google Scholar and EBSCO after 2,000 yielded the most significant results. To clarify the definitions of artificial intelligence (AI) and the element of emotional intelligence (EI) and reconcile them with the notion of holistic artificial intelligence/sapience (HAI), several keyword combinations have been tested to conduct a systematic literature review – SLR (Moher, Liberati, Tetzlaff, & Altman, 2009). Using the SLR, articles are selected based on the presence of EI definitions in the context of AI. EI definitions are collected for secondary data analysis (Vartanian, 2010).

Figure 3.1: Identification of Studies Via Databases and Registers



Articles were removed in three rounds.

1) Duplicates

2) Removal of non-scientific publications

3)Removal of articles without required Natural Language Processing, Holistic Artificial Intelligence, or General Artificial Intelligence with inclusion or, at a minimum, acknowledgment of, Emotional Intelligence

3.3 Defining Attributes

Each definition was categorized into sections, which, after review, provided a clear view of the attributes used and how common they may be. Specifically, the attributes related to process, outcomes, and context.

The attributes were determined using the framework outlined in Gerring (1999).

Concept formation' conventionally refers to three aspects of a concept:

(a) The events or phenomena to be defined (the extension, denotation, or definiendum)

(b) The properties or attributes that define them (the intention, connotation, definiens, or definition)

(c) A label covering both a and b (the term).

Concept formation is thus a triangular operation; good concepts attain a proper alignment between a, b, and c."

Following Gerring (1999), each definition's attributes are compared to specify the components as they exist in the literature, as detailed in appendix B. These attributes are also considered the basis of the AEI research program (Sfetcu, 2015). Accordingly, a sapient artificial intelligence must include awareness that other minds experience emotions in order to distinguish them from the other less sophisticated forms of artificial intelligence defined above.

Approaching artificial intelligence and emotional intelligence research requires the definition of two complex and abstract concepts to prepare the research to benefit academics and practitioners alike. This fundamental exercise endeavors to clarify these concepts so that an emotionally intelligent machine can be viewed more correctly and with greater detail to impact future research and development.

CHAPTER 4
FINDINGS

Reaching a holistic artificial intelligence, which is more similar to human intelligence, requires the inclusion of the context that makes an exploration, expansion, or action correct, which is often related to human emotional intelligence, as that is what underpins morality, societal perception of correctness and the interpretation of external data.

Artificial intelligence has also changed since its inception in the mid-20th century. What was initially perceived by academics and practitioners alike as an intellectual pursuit is now more of an area of study and creation. The definitions explored have highlighted the concept as a scientific field, a computer science, and an engineering pursuit. While technological convergence is occurring in large language models, the current state of artificial intelligence has not yet centralized around a specific implementation. If AI were viewed in this manner, as a single product or device, such as the role played by early computers developed by Xerox, IBM and Comodore. In that case the perspective limits the capacity to engage in higher types of systems and goals that require complex systems interlaced across multiple machines, data streams, and goals.

Progression in the field of artificial intelligence also assumes a goal of passing the Turing test and that sapience is the key to passing this test. Passing the Turing test includes the ability to mimic the things that make us human, which includes the emotional intelligence to create awkward interactions.

4.1 Preliminary Results

Characteristics of Definitions of Artificial Intelligence and Emotional Intelligence

1) “Intelligence that is marked by the abilities to recognize emotions (both of others and oneself), generate and adapt emotions, and apply emotional information in goal accomplishment and problem-solving. A precondition of these abilities is differentiating between different emotions.” (The Age of Artificial Emotional Intelligence)

2) “As a vital part of human intelligence, emotional intelligence is defined as the ability to perceive, integrate, understand, and regulate emotions.” (Emotional Artificial Intelligence: Fiction or Reality.)

3) “Emotions are physical experiences universal to all humans, and many other animals. Robots are expected to become capable of perceiving others’ emotions, develop their emotional state and manifest it” (Emotional machines: The next revolution)

4) “Emotional Intelligence became prominent in the late 1980s; however, Thorndike (1920) discussed a similar concept called social intelligence much earlier, in 1920 Copyright © 2008, Association for the Advancement of Artificial Intelligence (www.aaai.org). All rights reserved (Thorndike, 1920). While one’s social intelligence is typically defined by their “ability to understand and manage other people, and to engage in adaptive social interactions” (Kihlstrom & Cantor, 2000) emotional intelligence deals specifically with one’s ability to perceive, understand, manage, and express emotion within oneself and in dealing with others (Salovey & Mayer, 1990). Salovey and Mayer (1990) define five domains critical to emotional intelligence: knowing one’s emotions, managing emotions, motivating oneself, recognizing emotions in others, and handling relationships. A common measure of Emotional Intelligence is EQ (emotional intelligence quotient), as gauged by many widely published EQ tests.” (Emotional Computation in Artificial Intelligence Education)

5) “Agents is presented in Canamero (2003). According to this research ~ work, emotions are one of the mechanisms found in biological agents to better deal with dynamic, unpredictable, resource-limited, and general social environments, enhancing their autonomy and adaptation. In a high degree of autonomy, the agent has or can be attributed to some internal goals or motivations that drive its behavior” (Emotions in human and artificial intelligence)

6) “Affirms the importance of this type of emotionally influenced decision-making in computers. She suggests that if effective, emotionally intelligent decision making were integrated into computers, it would provide a clever solution to emulating the intelligence of humans, where decisions are often made with insufficient knowledge, limited memory, and relatively slow processing speeds.

Emotions are an integral part of human decision-making. Giving machines a similar mechanism could help solve problems where options cannot be fully explored, data is incomplete, and the processing time is short.” (Engineering Emotionally Intelligent Agents)

Table 4.1: Attributes of Reviewed Definitions of Artificial Intelligence & Emotional Intelligence

Article	Authors	Nature	Process	Outcomes	Context
The Age of Artificial Emotional Intelligence	Schuller and Schuller (2018)	Emotions of others and oneself	recognize emotions, generate (adapt and apply information)	Goal Accomplishment and problem solving	
Emotional Artificial Intelligence: Fiction or Reality.	Khizar and Shchyhelska (2018)		Perceive, integrate, understand and regulate		
Emotional machines: The next revolution	Franzoni, Milani, Nardi and Vallverdú (2019)	Processing other's emotions	emotional state development, emotional manifestation development		

(Continued**)**

Table 4.1 (Continued): Attributes of Reviewed Definitions of Artificial Intelligence & Emotional Intelligence

Article	Authors	Nature	Process	Outcomes	Context
Emotional Computation in Artificial Intelligence Education	Sood (2008)	With oneself, dealing with others emotions	Social Definition: understand, manage other people's emotions and engage in adaptive social interactions Intelligence definition: Perceive, understand and express within oneself and in dealing with others	handling relationships	
Emotions in human and artificial intelligence	Martınez-Miranda and Aldea (2005)	Mechanisms		Autonomy, adaptation, behavioural driving forces (goals/ motivations)	Dynamic, unpredictable, resource-limited

(Continued**)**

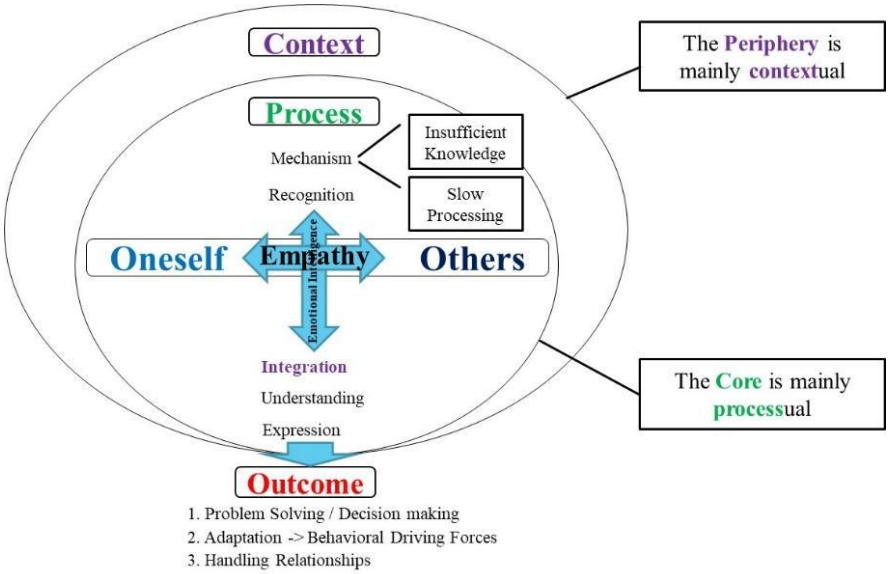
Table 4.1 (Continued): Attributes of Reviewed Definitions of Artificial Intelligence & Emotional Intelligence

Article	Authors	Nature	Process	Outcomes	Context
Engineering Emotionally Intelligent Agents	Baillie, Toleman and Lukose (2003).	part of human decision-making mechanisms	slow processing speed, options cannot be fully explored, short processing times	emotionally influenced decision making, problem solving	insufficient knowledge, limited memory

The inclusion of emotional intelligence must ensure that the Artificial Intelligence is Holistic and able to move towards similarity and effectiveness of the use of intelligence in decision making, significantly when data access is reduced, and processing cannot be conducted quickly.

In order to map the function of empathy into the implementation of a sapient artificial intelligence, the AI must understand its own existence, and the existence of other minds. In order to sufficiently meet this criterion in connection with humanity, the AI must have the capacity to understand that human minds different in their essential nature from the AI. Human minds experience emotion, which impacts their thinking and behavior. The capacity for the AI, which does not experience emotions itself, to meet this criterion requires a central role of empathy. In figure 4.2, the conceptual interlinkage for how such an AI would such an existence is described. This figure outlines how humans understand their own existence and how AI can therefore use similar components to understand the humanity in humans and build an empathy bridge.

Figure 4.1: Representation of the Proposed Components of Concepts of Emotional Artificial Intelligence as Reviewed in the Literature



4.2 Characteristics of Definitions of Emotional Intelligence

While the definitions of artificial intelligence vary more widely in literature than emotional intelligence, the characteristics below represent the majority reviewed. Interestingly, multiple definitions are often referenced in the same publication, an example of this incongruous phenomenon has been included in the review of definitions among selected papers. These definitions are included in the preliminary conclusions to indicate, at a high level, the types of emotional intelligence in humans and those referenced in the EAI derive from similar concepts and attributes, as illustrated in variety of processes listed in Table 4.1. Drawing from figure 2.1, which comprehensively maps the components of human emotional intelligence, this section will further examine these two aspects:

1) "As a vital part of human intelligence, emotional intelligence is defined as the ability to perceive, integrate, understand, and regulate emotions" (Mayer & Salovey, 1997; Mayer, Roberts, & Barsade, 2008)

2) Emotional Intelligence (EI) (...) is a kind of intelligence consisting of a set of 16-20 abilities grouped in 4 general groups labeled as I) perceiving emotions; II) integrating emotions in the facilitation of thoughts; III) understanding emotions; IV) regulating emotions. (Salovey & Mayer, 1990)

Emotional intelligence has been studied for centuries, and more agreed-upon definitions are utilized in research. The widely used definitions include a view of the basic definition, developed in 1990, and a more detailed reference to more categories of emotional intelligence, developed in 1997.

While artificial intelligence is defined as a specific part of research in a larger context, emotional intelligence has been researched specifically to define the concept. This has likely led to more agreement and consistency in the concept definition.

4.3 Overview of Initial Results

Previously, the concept of emotional intelligence has been excluded from artificial intelligence due to the erroneous belief that machines cannot be emotionally intelligent because they are not able to "feel." However, as shown in these concepts, the feeling is not accurate and certainly not as refined as regulating, creating, and understanding.

Current Artificial Intelligence systems will be unable to recognize, and discriminate emotions based on these concepts and the current understanding of training to create these types of Artificial Intelligence.

Further research into the ability to measure and evaluate the Emotional Artificial Intelligence understanding and including contextual data is necessary to create more robust and powerful machines in the future. This will ensure the holistic intelligence necessary to progress in artificial intelligence and emotional intelligence.

4.4 Refined Concepts

Combining the Gerring (1999)'s concepts with the research described herein, this paper proposed the following path forward. Artificial Emotional Intelligence should be understood as a necessary but insufficient dimension of Holistic Artificial Intelligence. HAI should be defined as:

An Artificial intelligence system which is able to recognize, understand, regulate, and respond to emotions, with human-like understanding of the impact of its' own actions and learn from the impact of its' decisions without the direct intervention of humans.

This new conceptualization allows for connection to the past through the incorporation of critical attributes from previous artificial intelligence concepts to further support the progression of the field while also incorporating more psychological attributes to solidify the expansion of intelligence beyond simple machine learning or computers to a holistic artificial intelligence with robust understanding and decision-making capabilities.

CHAPTER 5
DISCUSSION & CONCLUSION

Developing sapient artificial intelligence which possesses the necessary emotional intelligence to reach holistic artificial intelligence will allow academic and practitioner communities to move past the Turing test to evaluate if a machine can achieve sapient understanding instead of merely creating a sufficiently deceptive approximation. This will also require a new measurement and evaluation framework built on this concept, which will be explored in further research.

Lastly, this context definition will show the exact mapping of HAI and how it compares to other types of artificial intelligence, furthering the capacity of the field to engage in less task-specific and more intelligently complex activities.

5.1 Answer to Research Questions

Research Question 1:

How can emotional intelligence enhance the usefulness of artificial intelligence applications which focus on customer interactions? AI implementations which demonstrate sapience will be capable of delivering greatly enhanced user interactions. In order to achieve this, AI implementations will need to holistically incorporate emotional intelligence as a necessary but insufficient element. AI will demonstrate sapience when it can sufficiently utilize empathy to understand the differences between its sentience and the existence of human minds.

SQ1: What definition of emotional intelligence is most appropriate for this type of application? The capacity to know one's emotions, manage emotions, motivate oneself, recognize emotions in others, and handle relationships are the necessary will distinguish artificial sentience from artificial sapience.

SQ2: How does the field of artificial intelligence research integrate the concepts of emotional intelligence? Existing AI definitions do not well integrate the current research on human emotional intelligence. This paper provides a definition for integrating artificial emotional intelligence to enable AI to utilize an empathetic approach to understanding the nature of minds which incorporate emotions in a holistic manner.

5.2 Limitations of the Research

Future data review should include a significantly larger set, potentially beyond the focus of Natural Language Processing or Machine Learning and other, less rigorously conducted, research that has previously been excluded.

Exploring these concepts has come from a review of the literature. Artificial Emotional Intelligence is relatively recent, with most research being conducted in the past three years, drastically limiting the available literature for review.

Integrating definitions of emotional intelligence from psychology, with the artificial intelligence conceptual framework of technology, would provide a deeper understanding, validity, and reliability to promote consensus in the field.

Ultimately, the two definitions used for emotional intelligence were selected after the literature review determined that many researchers analyzing artificial intelligence and emotional intelligence followed the work of a single group, Salovey and Mayer (1990), and a specific period, 1990 to 1997.

5.3 Future Research and Next Steps

The rapid development of large language models and generative AI described in this paper indicate the urgent need to address artificial emotional intelligence. As implementations draw closer to sentience, and ultimately sapience, AI will play an ever larger role in economic development, science and commerce. In order to build appropriate safeguards, and develop implementations of maximal utility, the capacity to make reasoned decisions, informed by ethics, is of vital importance. Understanding the existence of other minds, and the role played by emotional intelligence in a sense of ethics, will be necessary to utilize AI for good. Future research should focus on the integration of continuing research in the field of human consciousness and the role of emotion in decision making, with the development of emerging areas of computer science applications.

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APPENDICES

Appendix A

Timeline of Conceptual Development Milestones in AI

1937 Alan Turing points out the limits of intelligent machines with the halting problem (Turing, 1937).

1943 McCulloch and Pitts model neural networks and make the connection to propositional logic.

1950 Alan Turing defined machine intelligence with the Turing test and wrote about learning machines and genetic algorithms (Turing, 1950).

1951 Marvin Minsky develops a neural network machine. With 3000 vacuum tubes, he simulates 40 neurons. 1955 Arthur Samuel (IBM) builds a learning checkers program that plays better than its developer (Samuel, 1959).

1956 McCarthy organizes a conference at Dartmouth College. Here the name Artificial Intelligence was first introduced. Newell and Simon of Carnegie Mellon University (CMU) present the Logic Theorist, the first symbol-processing computer program reference.

1958 McCarthy invents the high-level language LISP at MIT (Massachusetts Institute of Technology). He writes programs that are capable of modifying themselves.

1959 Gelernter (IBM) builds the Geometry Theorem Prover.

1961 The General Problem Solver (GPS) by Newell and Simon imitate human thought [NS61].

1963 McCarthy founds the AI Lab at Stanford University.

1965 Robinson invents the resolution calculus for predicate logic [Rob65] (Sect. 3.5).

1966 Weizenbaum’s program Eliza generates dialog with people in natural language [Wei66] (Sect. 1.1.2). 1969 Minsky and Papert show in their book Perceptrons that the perceptron, a very simple neural network, can only represent linear functions [MP69] (Sect. 1.1.2).

1972 French scientist Alain Colmerauer invents the logic programming language PROLOG (Chap. 5). British physician de Dombal develops an expert

system for diagnosing acute abdominal pain [dDLS+72]. It goes unnoticed in the mainstream AI community of the time (Sect. 7.3).

1976 Shortliffe and Buchanan develop MYCIN, an expert system for diagnosing infectious diseases, capable of dealing with uncertainty (Chap. 7).

1981 Japan begins, at great expense, the “Fifth Generation Project” to build a powerful PROLOG machine.

1982 R1, the expert system for configuring computers, saves Digital Equipment Corporation 40 million dollars annually [McD82].

1986 Renaissance of neural networks through, among others, Rumelhart, Hinton, and Sejnowski [RM86]. The system Nettalk learns to read texts aloud [SR86] (Chap. 9).

1990 Pearl [Pea88], Cheeseman [Che85], Whittaker, and Spiegelhalter bring probability theory into AI with Bayesian networks (Sect. 7.4). Multi-agent systems have become widespread.

1992 Tesauros TD-gammon program demonstrates the advantages of reinforcement learning.

1993 Worldwide RoboCup initiative to build soccer-playing autonomous robots [Roba].

1995 From statistical learning theory, Vapnik develops support vector machines, which are very important today.

1997 IBM’s chess computer Deep Blue defeats the chess world champion Gary Kasparov—Japan's first international RoboCup competition.

2003 The robots in RoboCup demonstrate impressively what AI and robotics can achieve.

2006 Service robotics has become a central AI research area.

2009 First Google self-driving car drives on the California freeway.

2010 Autonomous robots begin to improve their behavior through learning.

2011 IBM’s “Watson” beats two human champions on the “Jeopardy!” television game show. Watson understands natural language and can quickly answer detailed questions (Sect. 1.4).

2015 Daimler premiers the first autonomous truck on the Autobahn. Google self-driving cars have driven over one million miles and operate within cities. AI

becomes creative! Deep learning (Sect. 11.9) enables perfect image classification. Paintings in the style of the Old Masters can be automatically generated with deep learning.

2016 The Go program AlphaGo by Google DeepMind [SHM+16] beat the European champion 5:0 in January and Korean Lee Sedol, one of the world's best Go players, 4:1 in March. Deep learning techniques applied to pattern recognition, reinforcement learning, and Monte Carlo tree search led to this success.

Appendix B

Lexical Analysis of Definitional Components

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
High-Level Expert Group on Artificial Intelligence (2019)	Artificial intelligence (AI) systems are software (and possibly also hardware) systems designed by humans3 that, given a complex goal, act in the physical or digital dimension by perceiving their environment through data acquisition, interpreting the collected structured or unstructured data, reasoning on the knowledge, or processing the information, derived from this data and deciding the best action(s) to take to achieve the given goal. AI systems can either use symbolic rules or learn a numeric model, and they can also adapt their behaviour by analysing how the environment is affected by their previous actions.”	ü	ü	ü	ü	ü		ü	ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
EC Coordinated Action Plan on AI, 2018	"Artificial Intelligence refers to systems that display intelligent behaviour by analysing their environment and taking action — with some degree of autonomy — to achieve specific goals."								ü
European AI Strategy: EC Communication, Artificial Intelligence for Europe, 2018	"Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals."								ü
EC JRC Flagship report on AI: Artificial Intelligence. A European Perspective, 2018	"AI is a generic term that refers to any machine or algorithm that is capable of observing its environment, learning, and based on the knowledge and experience gained, taking intelligent action or proposing decisions. There are many different technologies that fall under this broad AI definition. At the moment, ML techniques are the most widely used."		ü	ü	ü	ü			

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
AI4Belgium Report, 2019	Reference to the European AI Strategy definition (section 3.1.1.3): 'According to the European Commission: "AI refers to systems that display intelligent behaviour by analysing their environment and taking actions – with some degree of autonomy – to achieve specific goals. AI -based systems can be purely software -based, acting in the virtual world (e.g. voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (e.g. advanced robots, autonomous cars, drones or Internet of Things applications)." '		ü	ü	ü	ü			
AI National Strategy: Denmark, 2019	"Artificial intelligence is systems based on algorithms (mathematical formulae) that, by analysing and identifying patterns in data, can identify the most appropriate solution. The vast majority of these systems perform specific tasks in limited areas, e.g. control, prediction and guidance. The technology can be designed to adapt its behaviour by observing how the environment is influenced by previous actions."		ü	ü	ü	ü		ü	

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
AI National Strategy: France. Monitoring report, 2019	Unofficial translation: A theoretical and practical interdisciplinary field, with objective the understanding of the cognitive and thinking mechanisms, and their imitation by a material and software device, for assistance or substitution purposes of human activities. The AI definition used is reported to be the one of Russell and Norvig (1995).	ü	ü	ü		ü			ü
Spanish RDI Strategy in Artificial Intelligence, 2019	"AI can be defined as the Science and Engineering that allows the design and programming of machines capable of carrying out tasks that require intelligence. Rather than achieving general intelligence, current AI focuses on what is known as specific AI, which is producing very important results in many fields of application such as natural language processing or artificial vision; however, from a scientific and basic and applied research point of view, general AI remains the major objective to be achieved, that is, creating an ecosystem with intelligent multitasking systems."	ü	ü	ü	ü	ü	ü	ü	

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
AI National Strategy: France (Villani Mission), 2018	"AI has always been envisioned as an evolving boundary, rather than a settled research field. Fundamentally, it refers to a programme whose ambitious objective is to understand and reproduce human cognition; creating cognitive processes comparable to those found in human beings. Therefore, we are naturally dealing with a wide scope here, both in terms of the technical procedures that can be employed and the various disciplines that can be called upon: mathematics, information technology, cognitive sciences, etc. There is a great variety of approaches when it comes to AI: ontological, reinforcement learning, adversarial learning and neural networks, to name just a few."	ü	ü	ü		ü			ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
AI National Strategy: Germany, 2018	"In highly abstract terms, AI researchers can be assigned to two groups: “strong” and “weak” AI. “Strong” AI means that AI systems have the same intellectual capabilities as humans, or even exceed them. “Weak” AI is focused on the solution of specific problems using methods from mathematics and computer science, whereby the systems developed are capable of self-optimisation. To this end, aspects of human intelligence are mapped and formally described, and systems are designed to simulate and support human thinking."	ü	ü		ü	ü			
AI National Strategy: Sweden, 2018	"There is no one single, clear-cut or generally accepted definition of artificial intelligence, but many definitions. In general, however, AI refers to intelligence demonstrated by machines."								ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Report of the Steering Group of the AI Programme: Finland, 2017	"Artificial intelligence refers to devices, software and systems that are able to learn and to make decisions in almost the same manner as people. Artificial intelligence allows machines, devices, software, systems and services to function in a sensible way according to the task and situation at hand."								ü
Australia's Ethic Framework, 2019	"A collection of interrelated technologies used to solve problems autonomously and perform tasks to achieve defined objectives without explicit guidance from a human being "		ü		ü		ü		
Working Paper for AI National Strategy: India, 2018	"AI refers to the ability of machines to perform cognitive tasks like thinking, perceiving, learning, problem solving and decision making. Initially conceived as a technology that could mimic human intelligence, AI has evolved in ways that far exceed its original conception. With incredible advances made in data collection, processing and computation power, intelligent systems can now be deployed to take over a variety of tasks, enable connectivity and enhance productivity."	ü	ü	ü	ü	ü	ü		

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
US National Defense Authorization Act, 2018	"1. Any artificial system that performs tasks under varying and unpredictable circumstances without significant human oversight, or that can learn from experience and improve performance when exposed to data sets. 2. An artificial system developed in computer software, physical hardware, or other context that solves tasks requiring human-like perception, cognition, planning, learning, communication, or physical action. 3. An artificial system designed to think or act like a human, including cognitive architectures and neural networks. 4. A set of techniques, including machine learning that is designed to approximate a cognitive task. 5. An artificial system designed to act rationally, including an intelligent software agent or embodied robot that achieves goals using perception, planning, reasoning, learning, communicating, decision-making, and acting."								ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
OECD, 2019	"An AI system is a machine-based system that can, for a given set of humandefined objectives, make predictions, recommendations, or decisions influencing real or virtual environments. AI systems are designed to operate with varying levels of autonomy."							ü	
OECD, 2018	AI can make business more productive, improve government efficiency and relieve workers of mundane tasks. It can also address many of our most pressing global problems, such as climate change and wider access to quality education and healthcare This combination of interdisciplinary origins, wavering trajectories, and recent commercial success make "artificial intelligence" a difficult concept to define and measure. The term itself is used interchangeably both as the still faraway goal of true machine intelligence and as the currently available technology powering today's hottest startups"		ü	ü	ü				

Source	AI Definition	Reasoning; Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
ETSI, 2018	“Computerized system that uses cognition to understand information and solve problems.” NOTE 1: ISO/IEC 2382-28 "Information technology -- Vocabulary" defines AI as "an interdisciplinary field, usually regarded as a branch of computer science, dealing with models and systems for the performance of functions generally associated with human intelligence, such as reasoning and learning".NOTE 2: In computer science AI research is defined as the study of "intelligent agents": any device that perceives its environment and takes actions to achieve its goals. NOTE 3: This includes pattern recognition and the application of machine learning and related techniques. NOTE 4: Artificial Intelligence is the whole idea and concepts of machines being able to carry out tasks in a way that mimics the human intelligence and would be considered "smart"	ü							

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
OECD, 2017	"Artificial Intelligence (AI) is a term used to describe machines performing human- like cognitive functions (e.g. learning, understanding, reasoning or interacting). It has the potential to revolutionise production as well as contribute to tackling		ü		ü				ü
World Economic Forum, 2017	"Artificial intelligence (AI) is the software engine that drives the Fourth Industrial Revolution. Its impact can already be seen in homes, businesses and political processes. In its embodied form of robots, it will soon be driving cars, stocking warehouses and caring for the young and elderly. It holds the promise of solving some of the most pressing issues facing society, but also presents challenges such as inscrutable "black box" algorithms, unethical use of data and potential job displacement. trust."								

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
World Economic Forum, 2017	As rapid advances in machine learning (ML) increase the scope and scale of AI's deployment across all aspects of daily life, and as the technology itself can learn and change on its own, multistakeholder collaboration is required to optimize accountability, transparency, privacy and impartiality to create "Artificial intelligence (AI) or self-learning systems is the collective term for machines that replicate the cognitive abilities of human beings. Within the broader technological landscape, predictive maintenance in the cognitive era has the								ü
ISO, 1993; 1995; 2015	"Branch of computer science devoted to developing data processing systems that perform functions normally associated with human intelligence, such as reasoning, learning, and self-improvement" (2121393: ISO, Al: term, abbreviation and definition standardized by ISO/IEC [ISO/IEC 2382-1:1993])								ü

Source	AI Definition	Reasoning; Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Tsinghua University, 2018	"AI machines do not necessarily have to obtain intelligence by thinking like a human and that it is important to make AI solve problems that can be solved by a human brain. Brain science and brainlike intelligence research and machine- learning represented by deep neural networks represent the two main development directions of core AI technologies, with the latter referring to the use of specific algorithms to direct computer systems to arrive at an appropriate model based on existing data and use the model to make judgment on new situations, thus completing a behavior mechanism In general, the artificial intelligence we know today is based on modern algorithms, supported by historical data, and forms artificial programs or systems capable of perception, cognition,		ü	ü	ü	ü	ü		ü
Kaplan and Haenlein (2019)	"Artificial intelligence (AI)—defined as a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation."								ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Poole et al., 2017; 2010; 1998	"Artificial intelligence (AI) is the established name for the field we have defined as computational intelligence (CI), Computational intelligence is the study of the design of intelligent agents. An agent is something that acts in an environment—it does something. Agents include worms, dogs, thermostats, airplanes, humans, organizations, and society. An intelligent agent is a system that acts intelligently: What it does is appropriate for its circumstances and its goal, it is flexible to changing environments and changing goals, it learns from experience, and it makes appropriate choices given perceptual limitations and finite computation."								ü
	"Artificial intelligence, or AI, is the field that studies the synthesis and analysis of computational agents that act intelligently.								

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Kaplan (2016)	"There is little agreement about what intelligence is. there is scant reason to believe that machine intelligence bears much relationship to human intelligence, at least so far."								ü
	"There are many proposed definitions on AI most are roughly aligned around the concept of creating computer programs or machines capable of behavior we would regard as intelligent if exhibited by humans."								
Stone et al.: AI100, 2016	""Intelligence" remains a complex phenomenon whose varied aspects have attracted the attention of several different fields of study, including psychology, economics, neuroscience, biology, engineering, statistics, and linguistics. Naturally, the field of AI has benefited from the progress made by all of these allied fields. For example, the artificial neural network, which has been at the heart of several AI-based solutions was originally inspired by thoughts about the flow of		ü	ü	ü	ü			ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Russell and Norvig, 2010 (3rd ed.); 1995	Four categories of AI are presented and eight definitions of earlier literature.								
	The categories are regarding thought processes, reasoning, human and rational behaviour. For more detailed information please refer to subsection 3.2.6.								ü
Bruner, 2009	"…any and all systems that process information must be governed by specifiable "rules" or procedures that govern what to do with inputs. It matters not whether it is a nervous system, or the genetic apparatus that takes instruction from DNA and then reproduces later generations, or whatever. This is the ideal of artificial								
	intelligence (AI), so-called."								ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
McCarthy (2007)	"It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable."								
	"Intelligence is the computational part of the ability to achieve goals in the world. Varying kinds and degrees of intelligence occur in people, many animals and some machines."	ü	ü	ü	ü				ü
Gardner (1999)	"A biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture."								ü
Nakashima, 1999	"Intelligence is the ability to process information properly in a complex environment. The criteria of properness are not predefined and hence not available beforehand. They are acquired as a result of the information processing."								ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Nilsson (1998)	"Artificial Intelligence (AI), broadly (and somewhat circularly) defined, is concerned with intelligent behavior in artefacts. Intelligent behavior, in turn, involves perception, reasoning, and learning, communicating, and acting in complex environments."	ü							ü
Neisser, et al. (1996)	The article introduces in the AI definition the notions of adapting to the environment, reasoning, learning etc. through a human intelligence definition, with multiple dimensions, due to biologically inspired processes.								ü
	"Individuals differ from one another in their ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought.								
	Concepts of intelligence are attempts to clarify and organise this complex set of phenomena."								

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Fogel (1995)	"Any system that generates adaptive behaviour to meet goals in a range of environments can be said to be intelligent."								ü
Wang, 1995	Intelligence is "the ability for an information processing system to adapt to its environment with insufficient knowledge and resources."								ü
Albus (1991)	"…the ability of a system to act appropriately in an uncertain environment, where appropriate action is that which increases the probability of success, and success is the achievement of behavioral subgoals that support the system's ultimate goal."								ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Schank (1991; 1987)	“AI suffers from a lack of definition of its scope. One way to attack this problem is to attempt to list some features that we would expect an intelligent entity to have. None of these features would define intelligence, indeed a being could lack any one of them and still be considered intelligent. Nevertheless each attribute would be an integral part of intelligence in its way. They are communication, internal knowledge, world knowledge, intentionality, and creativity.” “AI's primary goal is to build an intelligent machine. The second goal is to find out about the nature of intelligence.”								
	“Intelligence means getting better over time.”								ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
McCarthy (1988)	"The goal of artificial intelligence (A.I.) is machines more capable than humans at solving problems and achieving goals requiring intelligence. There has been some useful success, but the ultimate goal still requires major conceptual advances and is probably far off.								
	There are three ways of attacking the goal. The first is to imitate the human nervous system. The second is to study the psychology of human intelligence. The third is to understand the common sense world in which people achieve their goals and develop intelligent computer programs. This last one is the computer science approach."								ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Gardner (1987)	AI “seeks to produce, on a computer, a pattern of output that would be considered intelligent if displayed by a human being”. Schlinger (1992) mentions that this book also refers that “AI is viewed as a way of testing a particular theory of how cognitive processes might work. That theory is the popular information-processing model of cognition. Where AI researchers disagree, according to Gardner, is how literally to interpret the thinking metaphor. For example, some take what John Searle calls the "weak view" of AI, wherein computer programs are simply a means for testing theories of how humans might carry out cognitive operations. The weak view of AI is synonymous with modern cognitive psychology.”								ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Gardner, 1983	"Artificial intelligence is commonly defined by referencing definitions of human intelligence, as in Minsky's definition. In contrast to the standard approach of measuring one kind of intelligence (as in standard IQ tests), Gardner (cognitive scientist) offers an eight-dimensional definition to disentangle the oversimplification of intelligence's measurement. In particular, he proposed multiple conceptions of intelligence, not only logical- mathematical, linguistic, but also spatial, musical, bodily-kinaesthetic, personal."								ü
Newell and Simon, 1976	"By "general intelligent action" we wish to indicate the same scope if intelligence as we see in human action: that in any real situation behavior appropriate to the ends of the system and adaptive to the demands of the environment can occur, within some limits of speed and complexity."								ü

Source	AI Definition	Reasoning; Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Minsky, 1969	AI is “the science of making machines do things that would require intelligence if done by men”.								ü
McCarthy (1959)	The author, one of the founding father of AI, proposes that common sense reasoning ability is key to AI. “A program has common sense if it automatically deduces for itself a sufficiently wide class of immediate consequences of anything it is told and what it already knows.”								ü
McCarthy, et al., 1955	“..every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it. An attempt will be made to find how to make machines use language, form abstractions and concepts, solve kinds of problems now reserved for humans, and improve themselves. the artificial intelligence problem is taken to be that of making a machine behave in ways that would be called intelligent if a human were so behaving.”								ü

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Statista (2017 cited in European Union, 2020)	"Artificial Intelligence (AI) essentially refers to computing technologies that are inspired by the ways people use their brains and nervous systems to reason and make decisions, but typically operate quite differently."					ü	ü		ü
Andreas Kaplana Michael Haenleinb	Artificial intelligence (AI)—defined as a system's ability to correctly interpret external data, to learn from such data, and to use those learnings to achieve specific goals and tasks through flexible adaptation	ü	ü				ü		ü
Michael Haenlein, Andreas Kaplan	This introduction to this special issue discusses artificial intelligence (AI), commonly defined as "a system's ability to interpret external data correctly, to learn from such data, and to use those leanings to achieve specific goals and tasks through flexible adaptation."								

Source	AI Definition	Reasoning: Planning	Learning	Communication	Perception	Integration & Interaction	Services	Ethics & Philosophy	Other/NA
Shi Zhongzhi	Artificial intelligence is a branch of computer science- a discipline to study machine intelligence, - that uses artificial methods and techniques for developing intelligent machines or intelligent systems to emulate, extend and expand human intelligence and realize intelligent behavior								ü
Shi Zhongzhi	Artificial intelligence (AI) is usually defined as the science and engineering of imitating, expanding and augmenting human intelligence through artifical means and techniques to make intelligent machines.								ü

BIODATA

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