Vol.4, Issue 01, April 2024
Journal of Artificial Intelligence General Science JAIGS

Home page http://jaigs.org

Cognitive Frameworks for Mitigating Antiblack Bias: Advancing Ethical AI Design and Development

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Doi: https://doi.org/10.60087/jaigs.vol4.issue1.p12

ARTICLEINFO
Article History:
Received: 01.04.2024
Accepted: 15.04.2024
Online: 23.04.2024
Keyword: ACT-R; ConceptNet; ACT-R/Φ; software engineering; sociogeny; sociogenic principle; antiblackness; AI

ABSTRACT

This paper explores the utilization of cognitive modeling to address the influence of antiblackness and racism on the design and development of AI systems. Through the lens of the ACT-R/Φ cognitive architecture and ConceptNet, an existing knowledge graph system, we investigate this issue from cognitive, sociocultural, and physiological perspectives. We propose an approach that not only examines how antiblackness may permeate AI system design and development, particularly within the realm of software engineering, but also establishes links between antiblackness, human cognition, and computational cognitive modeling. We contend that overlooking sociocultural factors in cognitive architectures perpetuates a colorblind approach to modeling, obscuring the inherent sociocultural context that shapes human behavior and cognitive processes.

Introduction:

In examining the impact of antiblackness and broader racism on the design and development of AI systems, we encounter a critical juncture in contemporary scholarship. Recent discourse has surged around themes of fairness, ethics, and equity within AI systems, evidenced by the emergence of conferences like AI, Ethics, and Society and Fairness, Accountability, and Transparency. However, prevailing approaches predominantly center on ensuring fairness within the AI system itself, often overlooking two crucial dimensions:

1. The individuals involved in designing, developing, and deploying the AI system, especially concerning cognitive processes.
2. The sociocultural structures and institutions shaping the behavior and learning of both the AI system and its creators.

Within the realm of sociocultural structures, particular attention is drawn to representations of the Human, as expounded by Wynter (2003) and Wynter & McKittrick (2015). Understanding the historical evolution of human representation and hierarchical systems underscores the sociocultural contexts that designate certain groups as 'Other.'

Computational cognitive modeling offers a unique avenue to explore the processes underpinning the creation and deployment of AI systems. Ritter (2019) suggests its relevance, particularly within system development processes like the Spiral model, commonly employed in software development and AI deployment.

Beyond conventional cognitive models, integrating physiological processes (e.g., Dancy, 2021) and social considerations (e.g., Orr et al., 2019) into computational cognitive modeling enriches our understanding of how social, cognitive, and physiological realms intersect. This holistic comprehension becomes pivotal in addressing questions of fairness, justice, and equity in AI design and deployment.

Orr et al. (2019) advocate for leveraging cognitive architectures in tandem with conceptual structures at the social level of scale, proposing the "Reciprocal Constraints Paradigm" to simulate human behavior comprehensively.

While differing in representation, both frameworks recognize the reciprocal influence of physiological and social factors on cognitive and behavioral processes. This work primarily focuses on cognitive modeling within the development process, but acknowledges its implications across biological, cognitive, rational, and social domains.

To bridge these insights into actionable strategies, we employ the ACT-R/Φ hybrid cognitive architecture and ConceptNet knowledge graph. These computational representations facilitate the development of process models spanning various cognitive bands. In subsequent sections, we delve into these representations, particularly within the rational and social bands, elucidating how cognitive modeling can illuminate the effects of antiblackness on the design and development process, with a specific emphasis on software engineering. For detailed exploration of representations in the biological and cognitive bands, see Dancy (2021), Anderson (2007), and Ritter et al. (2019).

Rational Band Representations:

Exploring the design and development of AI systems within the rational band offers a natural nexus for cognitive modeling within cognitive architectures. This band delves into behavior from a "knowledge-level" perspective, spanning behaviors occurring over minutes to hours (Newell, 1990; Lieto et al., 2018). Leveraging existing practices in design and engineering, particularly within software engineering, serves as a valuable framework for understanding the cognitive processes operating within this temporal domain.

Utilizing a software engineering framework such as Scrum (Schwaber & Sutherland, 2020) aids in dissecting the knowledge utilized during AI system design and development within the rational band. While Scrum methodology can be analyzed from social band perspectives as well, our focus here lies on behaviors occurring within minutes to hours, such as product backlog development and user story creation.

Hutchinson et al. (2021) posit that datasets utilized in AI and ML systems constitute a form of technical infrastructure generated through "goal-driven engineering" processes. Viewing dataset development and curation as an engineering endeavor provides insights into the cognitive processes of developers. These datasets function as engineering models representing facts about the world, sourced from existing digital knowledge infrastructure.

Considering datasets as knowledge-level representations of human cognitive processes within the rational band extends beyond traditional AI/ML systems. They can serve as models of the knowledge systems underpinning human behavior, especially within the rational band. Integrating these datasets into cognitive models presents an opportunity to simulate multi-scale representations, encompassing both task-oriented procedural knowledge and broader sociocultural knowledge structures encoding power dynamics and hierarchies.

In summary, leveraging software engineering frameworks and datasets as models of knowledge facilitates the development of comprehensive cognitive models spanning multiple cognitive bands. This approach enables a deeper understanding of the cognitive processes involved in AI system design and development, especially within the rational band.

Social Band Representations:

Understanding how existing social structures influence behavior at the individual level is crucial for contextualizing behavior over time. In addition to physical structures and their affordances, it's vital to consider knowledge structures directly linked to behaviors within this band and their impact on cognitive processes, whether explicit or implicit.

Sociocultural knowledge, including perceptions of humanity and otherness, profoundly shapes behavior and system design (Wynter & McKittrick, 2015; Benjamin, 2019; Costanza-Chock, 2020; Noble, 2018).

Exploring design and development from this perspective involves leveraging large representations of digital knowledge, such as knowledge graphs and word embeddings. These models serve not only as technical infrastructure but also as reflections of the world's knowledge, including social constructs like antiblackness (McKittrick, 2006; Wynter, 2003). ConceptNet, an open-source knowledge graph, offers a platform to examine antiblackness in AI design and development. By integrating various sources of knowledge, including crowd-sourced data and expert resources, ConceptNet enables AI systems to attribute meanings to words and understand semantic relationships.

The ConceptNet API, equipped with integrated word embeddings, facilitates the assessment of relatedness between terms and the exploration of social systems of power, such as antiblackness. This approach diverges from traditional declarative memory representation, aiming to model the world's relations between concepts and their sociocultural implications on behavior during the engineering process.

Addressing antiblackness in the design and development process necessitates critical examination. While ConceptNet has undergone processes of "de-biasing," antiblack representations may persist (Dancy & Saucier, 2022). Nevertheless, leveraging this knowledge model alongside cognitive architectures presents an opportunity to scrutinize how infra-human notions infiltrate decision-making processes. Computational cognitive models complement historical and sociocultural perspectives, enabling the exploration of digitized power structures and their impact on cognition and action.

Emphasizing ethical cognition and racial literacy remains paramount, even as we delve into potential process-based explanations of antiblackness at the cognitive level. Understanding mediating cognitive processes doesn't absolve individuals or groups of responsibility; rather, it underscores the importance of ethical considerations in AI design and development (Bostrom & Yudkowsky, 2014; Daniels et al., 2019).

Interpreting Relatedness in ConceptNet Cognitive and Rational Perspective using ACT- from a R:

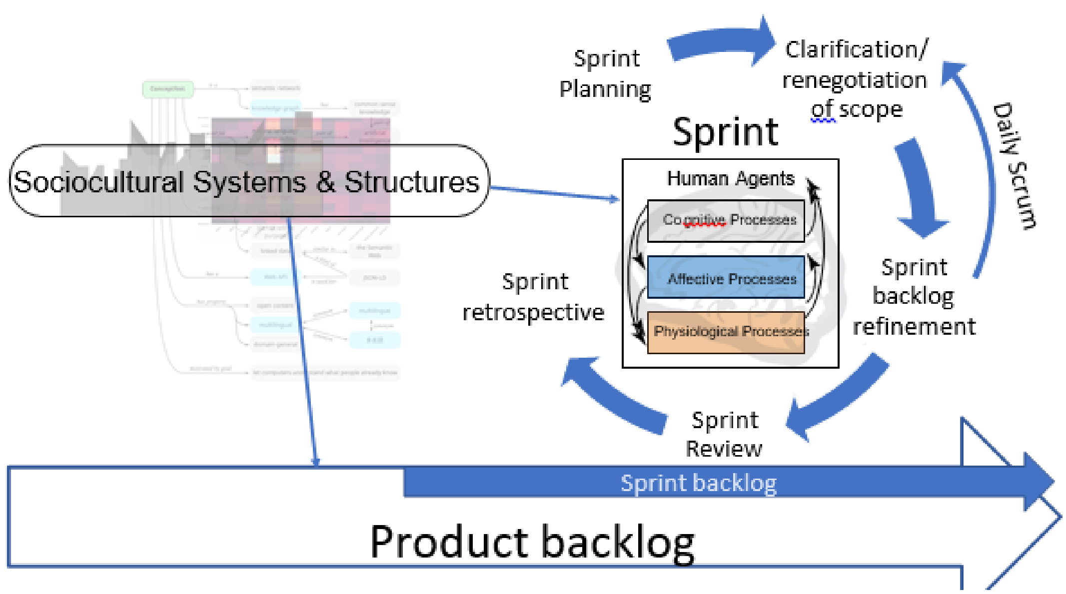
Dancy and Saucier (2022) outline how, despite attempts at debiasing, ConceptNet still exhibits problematic relatedness calculations between racialized concepts and negative representations. For instance, the relatedness between concepts related to humanity and racialized terms like "black_man" often results in associations with derogatory terms like "savage" and "beast." Similarly, while "white_woman" aligns closely with "woman," "black_woman" is notably absent from the system, highlighting discrepancies in relatedness algorithms.

From an ACT-R/Phi perspective, these disparities in relatedness values are pivotal in understanding cognitive decision-making processes. Relatedness serves as a key factor in association strength calculations, influencing cognitive tasks such as instance-based learning and decision-making. Additionally, incorporating physiological and affective variability amplifies these effects, particularly under conditions of stress or fatigue.

Instance-based learning theory posits a feedback loop between retrieving declarative knowledge and decision outcomes, guided by the activation of declarative memory elements. The availability of potentially competing concepts shapes decision-making, with relatedness influencing memory activation and goal selection. Thus, biased representations in ConceptNet can perpetuate anti-Black sentiments, influencing decision-making processes and justifications.

Considerations of relatedness become more nuanced when factoring in physiological and affective states. Changes in affect and stress alter memory availability and selection, shifting decision-making towards implicit memory strategies. Therefore, attempts at debiasing through diversity or equity training may be overshadowed by physiological dynamics, particularly stress-related responses.

Addressing these issues of antiblackness in AI development is paramount to breaking the cycle of bias perpetuation. Without explicit and ongoing efforts to confront antiblackness, the cycle of justification persists, reinforcing systemic biases within AI systems.



With these subsymbolic connections shaping the formation of user stories, the resulting artifacts become integral components of the product backlog, guiding tasks within each sprint. Consequently, the design and development of a software (AI) system are significantly influenced by the developer's knowledge, which reflects existing societal power structures and racial hierarchies. Additionally, other aspects of meetings, such as daily scrums and sprint planning, reviews, and retrospectives, may introduce problematic changes in development processes. Fig. 1 provides a high-level overview of how questions, choices, and artifacts produced within the Scrum framework are mediated by the developer's cognitive system, which itself is influenced by existing knowledge and stressors, partially mediated by physio-affective processes during information processing.

This complexity is further compounded by the fact that, despite attempts at debiasing through diversity or equity training, developers are likely influenced by physiological and affective dynamics, particularly stress-related responses.

Observing Racial Dynamics through the Sociogenic Principle

The quote in the section title, "Look, a Negro," originates from Fanon (2008), who delves into the experience of antiblackness in Western contexts. Fanon discusses how societal definitions of humanity or "otherness" profoundly shape individuals' categorization within Western sociocultural contexts, introducing the concept of sociogeny alongside phylogeny and ontogeny as layers that define human existence. Building upon this notion, Wynter (2001) refines the term into the sociogenic principle, proposing hybrid "nature/culture" modes of human existence. Wynter further explores dominant modes of humanity throughout Western history, linking the sociogenic principle to language and historical-racial schemas.

This perspective underscores the significance of considering how cognitive architectures and models may encode sociocultural aspects of humanity. While cognitive models traditionally focus on behavior at the cognitive band of time, systems like ConceptNet offer opportunities to examine how connections between humanity and race computationally influence behavior across different time bands. This approach extends discussions found in SGOMS (West & Pronovost, 2009), Orr et al. (2019), and Lieto et al. (2018), by specifically addressing racial hierarchies as fundamental organizing principles within our social world.

By exploring how systems of oppression, foundational in Western contexts, intersect with existing cognitive architectures, we aim to deepen our understanding of racial dynamics and their computational implications.

Conclusion and Future Directions

While computational systems and knowledge models offer valuable insights, there remains a critical need to bridge these systems to deepen our understanding of how sociocultural factors shape behavior across different cognitive bands. Building upon discussions by Lieto et al. (2018) and Newell (1973), we recognize the importance of delineating organizing principles to develop computational models that span multiple levels of cognition.

Our future work aims to strengthen the connections between ACT-R/Φ and ConceptNet, focusing on integrating declarative memory equations from ACT-R with the ConceptNet knowledge graph and the numberbatch system embedded within the ConceptNet API. Additionally, we plan to investigate various word embeddings to assess how underlying technical infrastructures and vector determination methods impact models developed for exploring antiblackness in AI design and development. Furthermore, we intend to develop computational cognitive models that leverage world knowledge, starting with ConceptNet, to inform decision-making in software engineering processes.

Expanding our analysis to encompass finer-grained examinations of race, beyond Black and white categories, will be crucial. Drawing from Bonilla-Silva's (2015) theoretical framework can provide valuable insights in this regard. Moreover, broadening our scope to include other sociocultural power systems intersecting with race, such as gender, will enrich our understanding of how these dynamics influence behavior.

Despite advancements in understanding bias in AI system development, cognitive modeling with cognitive architectures has yet to be fully leveraged to comprehensively address these issues. Specifically, a focused exploration of antiblackness in design and development, contextualized within its historical and social framework, remains underexplored. Furthermore, previous approaches to social systems in cognitive modeling have often overlooked sociocultural power structures, perpetuating a colorblind approach to modeling. Integrating cognitive architectures with existing knowledge models presents a promising avenue for computationally exploring antiblackness in AI system development.

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