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Jugaad: The Untranslatable Innovation Confounding AI and ML

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ABSTRACT

This paper examines the concept of *jugaad*, which embodies a cultural approach to innovation in the face of resource scarcity, originating as a byproduct of such scarcity in the Indian subcontinent centuries ago. Specifically, this paper examines the uniquely untranslatable nature of the word, highlighting linguistic and cultural nuances that cause both traditional Artificial Intelligence (AI) and Machine Learning (ML) approaches and more novel Natural Language Processing (NLP) approaches to fail to capture the true essence of the concept. In addition, this paper explores the ethical implications of how cultural concepts fit into the future of large models. This research not only sheds light on the complex interplay between language, culture, and innovation but also highlights the limitations of current computational linguistics models in capturing the essence of culturally entrenched concepts.

Introduction

The concept of *jugaad* has emerged as a fascinating subject of study in recent years, capturing the attention of scholars across multiple disciplines, from cognitive and computational linguistics to management and research. Originating from the Hindi language, the word jugaad represents a uniquely Indian approach to problem-solving that embodies resourcefulness, adaptability, and innovation in the face of seemingly insurmountable constraints. This paper aims to explore the multifaceted nature of jugaad, with a particular focus on its deep roots in Indian history, culture, and language; and on the computational challenge posed by its uniquely untranslatable nature.

The untranslatability of jugaad presents an intriguing challenge for computational experts, linguists, and translators alike. It serves as a prime example of how language can encapsulate complex cultural phenomena that resist simple translation into other formal linguistic frameworks. By examining jugaad through the lens of linguistic anthropology and translation studies, we can gain valuable insights into the intricate relationship between language, culture, and cognition.

This paper will briefly delve into the historical and cultural context that gave rise to the concept of jugaad, analyze its linguistic properties, explore its contemporary applications in the Indian societal context, and examine its growing global recognition. Through a comprehensive literature review and critical analysis, we will also identify gaps in current research and propose directions for future studies on this rich and complex topic.

The study of jugaad and its untranslatability is of paramount contemporaneous importance in our increasingly globalized and technologically driven world. As AI and ML systems become increasingly ubiquitous in cross-cultural communication and decision-making processes, understanding and accurately representing culturally nuanced concepts like jugaad becomes critical. Moreover, exploring jugaad can provide valuable insights into alternative approaches to innovation and problem-solving, enhance our understanding of diverse cognitive frameworks, and potentially offer novel solutions to global challenges, especially in resource-constrained environments.

Historical Context of *Jugaad* and Contemporary Application

The roots of jugaad can be traced back to pre-colonial India. Jugaad can be understood as an immediate, inexpensive, and innovative solution to a problem, for which no immediate solution is readily available. The term jugaad, loosely meaning "put-together," is mostly used colloquially for innovative solution-focused problem-solving techniques and draws its origin in Punjab where farmers would often put together unrelated discarded auto parts and use an irrigation pump as an engine to come up with an assembled indigenous vehicle used for farming and even transporting people (Prakash et al, 2019).

The concept gained prominence during the colonial era, as Indians devised creative ways to circumvent the restrictions imposed by British rule on Indian citizens. In the post-independence era, jugaad became an essential strategy for businesses and individuals to navigate the complex bureaucratic landscape that stifled commerce and innovation in India.

The cultural context that nurtured jugaad was marked by resource scarcity, systemic inefficiencies, and a collective Indian ethos that values adaptability and resilience. This environment cultivated a mindset that prioritizes finding workable solutions over adhering to rigid, formal processes (Prahalad & Mashelkar, 2010), and encouraged creative solutions in the absence of easy spare parts and a robust after-sales support infrastructure in the country. The jugaad approach reflects a deep-seated cultural value of "making do" with available resources, a trait that has been simultaneously celebrated as a sign of ingenuity and criticized as a potential hindrance to systemic improvement and innovation (Birtchnell, 2011).

In modern India, jugaad continues to play a significant role across various sectors of society and the Indian economy. In rural areas, it often manifests as innovative solutions to agricultural challenges or the creation of low-cost alternatives to expensive machinery (Gupta, 2016), while in urban settings, jugaad has become associated with an entrepreneurial spirit and startup culture, where it is seen as a valuable approach to innovation in resource-constrained environments (Prabhu, 2017). Thus, correctly, Forbes magazine called jugaad the art of converting adversity into opportunity.

However, the perception and application of jugaad vary across social strata. While it is often celebrated in grassroots contexts and among small-scale entrepreneurs, some critics argue that an overreliance on jugaad hinders the development of more robust, scalable systems and indeed stifles systemic innovation by focusing on fixes rather than on improvements. This tension between jugaad as a source of innovation and as a potential obstacle to systemic improvement remains a subject of heated debate within Indian society and outside.

Literature Review

The scholarly literature on jugaad has expanded significantly in recent years, reflecting the growing interest in the concept across multiple disciplines. Early studies focused primarily on understanding and defining jugaad and explaining it within the context of Indian culture and business practices (Rangaswamy, 2013). More recent research has explored its applications in various fields, including:

1. Innovation management: several studies have examined how jugaad principles can be applied to foster innovation in resource-constrained environments, both in India and globally (Prahalad & Mashelkar, 2010).

2. Entrepreneurship: researchers have investigated the role of jugaad in supporting entrepreneurial activities, particularly in the context of emerging economies (Prabhu & Jain, 2015).

3. Sustainable development: some scholars have explored how jugaad approaches can contribute to sustainable development goals, especially in addressing challenges in low-resource settings (Basu et al, 2013).

4. Organizational behavior: studies have examined how a jugaad mindset can influence organizational culture and decision-making processes (Sharma & Iyer, 2012).

5. Linguistic anthropology: researchers have analyzed jugaad as a culturally embedded concept that reflects broader patterns of thought and behavior in Indian society (Jeffrey & Young, 2014).

Despite this growing body of literature, however, there remain significant gaps in our understanding of jugaad, particularly in terms of its linguistic properties, its cognitive implications, and its potential applications in diverse global contexts.

Recent studies have begun to explore the challenges of incorporating culturally specific concepts like jugaad into computational linguistics and artificial intelligence systems. The field of computational linguistics has long grappled with the challenge of translating culturally specific concepts across languages and computational algorithms. Jugaad presents a particularly interesting case study in this domain. Multiple researchers have noted that traditional machine translation systems often fail to capture the nuanced meaning of jugaad, typically defaulting to oversimplified translations like *hack* or *makeshift solution.*

One of the key challenges in incorporating jugaad into AI and ML systems lies in the concept's context-dependent nature. According to Herschcovich, cross-cultural natural language processing (NLP) models face challenges stemming from divergent conceptualizations across cultures, which affect language use and interpretation (Hershcovich et al, 2022). Several studies have attempted to address this challenge, and researchers have experimented with advanced contextual embedding models such as BERT (Bidirectional Encoder Representations from Transformers) to better capture the nuanced meanings of culturally specific terms like jugaad. These models aim to understand words in context rather than in isolation, potentially allowing for more accurate interpretations of jugaad under different scenarios.

Other studies have explored techniques for transferring knowledge about culturally specific concepts from one language to another. Researchers have highlighted the importance of incorporating cultural knowledge into NLP models to better represent and process culturally specific concepts (Hovy & Spruit, 2016). This approach could potentially be applied to enrich English language models with a contextual understanding of Hindi concepts like jugaad. There's also growing interest in developing AI systems that are more culturally aware and capable of understanding and generating culturally specific content that incorporates cultural knowledge bases into language models, allowing them to better interpret and generate text involving concepts like jugaad.

Despite these significant efforts, many challenges remain. Current AI systems struggle to fully grasp the improvisational and adaptive nature of the word, which reflects the broader challenges in AI's ability to understand and replicate human creativity and contextual problem-solving. As importantly, the ethical implications of incorporating culturally specific concepts like jugaad into AI systems have been a subject of debate on the risks posed by cultural appropriation or misrepresentation when these concepts are adapted for use in global AI systems (Sambasivan et al, 2021).

Future research in this area could focus on (i) developing more sophisticated cultural knowledge bases for AI systems; (ii) exploring the use of multimodal AI models that can understand jugaad not just in text, but also in visual and contextual information; (iii) investigating how jugaad-like thinking could be incorporated into AI problem-solving algorithms itself; and (iv) examining the ethical considerations of embedding culturally-specific concepts in global AI systems.

Linguistic Analysis of *Jugaad*

From a purely linguistic standpoint, jugaad presents a fascinating case study in semantic evolution and cultural embeddedness. The word itself is believed to have originated from the Hindi verb "*jugaadna*," meaning to hack or to devise. Over time, it has evolved into a noun that encompasses a broad range of meanings, from a mundane makeshift solution to a profoundly philosophical approach to problem-solving and life itself.

Its morphological simplicity - a single, disyllabic word - belies the complexity of its semantic content, which has expanded significantly as the concept has gained cultural prominence and worldwide intrigue.

Semantically, jugaad operates on multiple levels. At its core, it denotes a practical solution or workaround, but it also carries connotations of creativity, resourcefulness, and a particular cognitive approach to problem-solving. This semantic richness contributes to its untranslatability, as no single word or phrase in English can capture the full range of meanings and cultural associations embedded in jugaad.

One of the primary reasons jugaad resists straightforward translation is its contextual flexibility. Jugaad often means different things in different contexts. In a business context, it might refer to frugal innovation or a creative workaround. In everyday life, it could mean a quick fix or a makeshift solution. And in a broader societal context, it may represent a mindset of resourcefulness and adaptability. This contextual flexibility makes it difficult to find a single English word or phrase that captures all these nuances.

Jugaad is also deeply embedded in Indian culture and socio-economic conditions, which adds layers of meaning that are lost in translation. In his book "*Being Indian*," Pavan Varma explains that jugaad emerges from a specific cultural context of resource scarcity and systemic constraints. It embodies not just a way of problem-solving, but a cultural attitude towards adversity (Varma, 2006). For example, when a rural Indian farmer repurposes a water pump motor to create a vehicle (locally known as a "*jugaad*"), the act represents more than just creating a makeshift vehicle. It simultaneously embodies the ingenuity born out of necessity, a cultural value of "making do" with available resources, and a critique of systemic inefficiencies that necessitate such solutions. These cultural and socio-economic dimensions are difficult to convey in a simple translation, making jugaad resistant to straightforward linguistic equivalence.

The complex, culturally embedded nature of jugaad poses significant challenges in the field of computational linguistics, particularly for AI and ML systems. These systems, which rely on pattern recognition and statistical analysis, often struggle to capture the nuanced, context-dependent meanings of culturally specific concepts like jugaad (Bender & Koller, 2020). The concept's resistance to straightforward translation and its deep cultural roots make it difficult for machine learning algorithms to accurately interpret and generate text involving jugaad, especially in cross-lingual contexts. This challenge highlights the limitations of current NLP models in handling culturally rich, semantically complex terms, and underscores the need for more sophisticated approaches that can incorporate cultural context and connotative meanings (Hovy & Spruit, 2016).

Untranslatability and Cultural Semantics

The untranslatability of jugaad is rooted in its deep cultural embeddedness and the unique cognitive framework it represents. According to the Sapir-Whorf hypothesis, the structure of a language determines a native speaker's perception and categorization of experiences, or language shapes thought patterns and worldviews (Deutscher, 2010). In this context, jugaad can be seen as a linguistic manifestation of a distinctly Indian approach to navigating challenges and constraints. And so, it begs the question of whether an interpretation or even an application of the concept holds any meaning outside of the specific worldview and circumstantial compulsions from which it is born.

Attempts to translate jugaad into English often result in overly simplified and partial equivalents that fail to capture the positive connotations of innovation, ingenuity, and resourcefulness that jugaad carries in Indian culture, while also lacking the socio-economic context and historical depth that are inextricably connected to the concept.

The untranslatability of jugaad also highlights the limitations of cross-cultural communication and the challenges faced in global business and academic discourse. As jugaad gains recognition in international contexts, there is a risk of its meaning being diluted or misinterpreted when divorced from its original cultural context (Sekhsaria, 2013).

To address these challenges, computational linguistics researchers are exploring various approaches within AI/ML systems. One promising direction is the development of culturally-aware language models that incorporate not just linguistic data but also cultural knowledge bases (Chen & Cardie, 2018). These models aim to capture the contextual and cultural nuances of concepts like jugaad by training on diverse, culturally rich datasets. Another approach involves the use of transfer learning techniques to bridge the gap between languages and cultures. For instance,

researchers have experimented with methods to transfer knowledge from Hindi language models to English ones, allowing for more nuanced interpretations in cross-cultural contexts (Desai & Dabhi, 2021). Additionally, multi-modal AI systems that can process both textual and visual information are being explored as a way to better understand and represent culturally specific concepts, which often manifest in physical innovations as well as linguistic jargon.

Global Perspectives on *Jugaad*

As India's economic influence has grown on the global stage, the concept of jugaad has garnered international attention, particularly in the fields of management and innovation studies. Scholars and business leaders have begun to explore how its principles can be applied in various contexts, from product development in multinational corporations to addressing global challenges, particularly in resource-constrained environments (Ahuja & Chan, 2016).

The global interest in jugaad has led to its partial assimilation into English as a loanword, particularly in business and academic literature. However, this process of linguistic borrowing raises important questions about the extent to which the core meaning and cultural nuances of jugaad can be preserved when transplanted across and into different cultural contexts.

In the United States, particularly in Silicon Valley, jugaad has been adopted as a generic buzzword for frugal innovation and lean startup methodologies. However, this interpretation often grossly oversimplifies the concept, focusing primarily on its cost-cutting and rapid prototyping aspects while overlooking the deeper cultural context of systemic constraints and resource scarcity that gave rise to jugaad in India. For instance, when Facebook adopted "*Move Fast and Break Things*" as a motto, it was often compared to *jugaad*, but this comparison misses the crucial difference between *opting to work with self-selected constraints* (as in Silicon Valley) and *being forced to do* so by circumstances and with no choice at all (in India). Similarly, some Western business schools have incorporated jugaad into their innovation curricula, presenting it as a universally applicable approach to frugal innovation. However, this adoption often misinterprets jugaad as merely a set of techniques rather than a culturally embedded mindset and way of life.

But principles of jugaad have indeed been successfully applied by Western companies. For instance, an American healthcare company, Embrace Innovations, developed a low-cost infant warmer for use in developing countries, inspired by jugaad principles of frugal innovation and resourcefulness. Embrace's infant warmer is a perfect example of jugaad innovation: a frugal solution that is also flexible, as it works with or without electricity and inclusive, as it benefits even the poorest citizens of its countries (Radjou, 2023). This example demonstrates how jugaad principles have been adopted and applied in a Western context, specifically in healthcare innovation targeting developing markets. It highlights both the potential for cross-cultural application of jugaad and the challenges in translating this concept to different industrial and regulatory environments.

Conclusion

As we push forward on our exploration of jugaad, we find ourselves at a critical juncture where cultural concepts intersect with cutting-edge technology. The untranslatability of the word jugaad, far from being a mere linguistic curiosity, emerges as a profound challenge and opportunity for the fields of AI and ML.

The concept of jugaad pushes the boundaries of what we expect from these systems. Traditional approaches to natural language processing and machine translation, built on statistical models and literal translations, falter when confronted with the rich cultural context and adaptive problem-solving ethos embedded in jugaad. This limitation exposes a crucial gap in our current AI technologies: the ability to truly understand and operationalize culturally nuanced concepts.

For such systems to advance beyond mere pattern recognition and into the realm of genuine intelligence, they must grapple with concepts like jugaad. The improvisational nature of jugaad, its context-dependent applications, and

its embodiment of a particular worldview present a formidable challenge for machine learning models. How can we train an AI to not just recognize jugaad, but to think in terms of the concept – to see resources where others see constraints, to innovate when faced with scarcity?

This challenge opens up exciting new avenues for research. We envision future AI systems that can seamlessly navigate between cultures, understanding and even applying concepts like jugaad in appropriate contexts. Such systems would not just translate words but translate ways of thinking and worldviews. They could revolutionize fields from global business strategy to international diplomacy, offering insights and solutions that draw on the full spectrum of human ingenuity.

Moreover, the study of jugaad in AI contexts prompts us to reconsider the very foundations of AI. Current models, largely developed in Western contexts, could inadvertently embed certain cultural assumptions about problem-solving and innovation. It is only by incorporating diverse concepts like jugaad, that we can work towards creating more globally inclusive AI systems – systems that reflect and respect the rich tapestry of human cognitive approaches.

The implications extend beyond technical capabilities. As AI increasingly mediates our global interactions, its ability to grasp and convey culturally embedded concepts becomes a matter of ethical importance. A system that understands jugaad is a system that's one step closer to understanding the diverse ways humans approach challenges – a crucial skill in our interconnected world. The process of teaching AI to understand jugaad could yield profound insights into human cognition itself. As we break down this concept in the context of machine learning, we may uncover new layers of meaning and application, deepening our understanding of this rich cultural resource.

In the realm of computational linguistics, jugaad presents both a challenge and an opportunity. It challenges our current models of language processing and translation, pushing us to develop systems that can grasp and convey the full semantic and cultural richness of such concepts. At the same time, it offers an opportunity to advance the field, driving the creation of more nuanced, context-aware language models that can bridge linguistic and cultural divides.

Future Research Directions

The current state of research opens up several promising avenues for future investigation, each with significant implications for our understanding of cultural concepts and their role in an increasingly globalized world.

In the field of cognitive linguistics, further research is needed to explore how the concept of jugaad shapes cognitive processes and problem-solving approaches in India. This line of inquiry could provide valuable insights into the relationship between language, culture, and cognition, potentially informing our understanding of cultural variations in innovation and creativity.

Comparative studies offer another fruitful area for research. Cross-cultural studies comparing jugaad with parallel concepts in other cultures, such as "*bricolage*" in French or "*jiejin*" in Chinese, could provide valuable insights into cultural approaches to innovation and problem-solving. Such research could illuminate both the universal aspects of human ingenuity and the unique cultural expressions of resourcefulness and adaptability.

From a sociolinguistic perspective, more in-depth studies on how the use and interpretation of jugaad vary across different social, economic, and linguistic groups within India could enhance our understanding of its cultural significance. This research could reveal how the concept evolves and adapts within diverse subcultural contexts, providing a more nuanced picture of its role in Indian society.

In the realm of translation and localization, research on strategies for effectively communicating the concept of jugaad in different linguistic and cultural contexts could have important implications for cross-cultural management and international business. This work is crucial for facilitating meaningful cross-cultural dialogue and collaboration in an increasingly interconnected global economy.

Applied linguistics offers yet another avenue for exploration. Investigating how the concept of jugaad could be incorporated into language teaching and intercultural communication training programs could enhance cross-cultural understanding and collaboration. This research could lead to more effective methods for bridging cultural divides and fostering global cooperation.

Perhaps most critically, the field of computational linguistics faces the challenge of developing natural language processing models that can accurately capture and analyze the use of culturally embedded concepts like jugaad in multilingual contexts. This research is vital for advancing the field of machine translation and cross-cultural text analysis, with far-reaching implications for global communication and understanding. The importance of getting this right for AI/ML systems cannot be overstated. As these technologies increasingly mediate our global interactions, their ability to accurately interpret and convey culturally nuanced concepts like jugaad becomes crucial. Without this capability, AI/ML systems risk perpetuating misunderstandings, reinforcing cultural biases, or simply failing to capture the rich diversity of human thought and expression.

Moreover, the process of adapting such systems to handle concepts like jugaad could yield valuable insights into the nature of human cognition and cultural variation. Such research could potentially lead to more flexible, adaptable AI systems that can better mimic human-like understanding and problem-solving across diverse cultural contexts.

Hence, future research directions surrounding jugaad and similar culturally embedded concepts are not just academic exercises, but crucial steps towards creating more culturally intelligent technologies and fostering genuine global understanding. As we continue to navigate an increasingly interconnected world, the ability to bridge linguistic and cultural divides - both in human interactions and in our technological systems - will be key to addressing global challenges and harnessing the full potential of our diverse human ingenuity.

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References

Ahuja, S., & Chan, Y. E. (n.d.). *Digital Innovation: A Frugal Ecosystem Perspective*. Internet Archive. https://web.archive.org/web/20231016061826id_/https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1009&context=icis2016

Basu, R. S., Banerjee, P. M., & Sweeney, E. G. (2013). Frugal Innovation: Core Competencies to Address Global Sustainability. *Journal of Management for Global Sustainability*, *1*(2). https://archium.ateneo.edu/jmgs/vol1/iss2/5/?utm_source=archium.ateneo.edu%2Fjmgs%2Fvol1%2Fiss2%2F5&utm_medium=PDF&utm_campaign=PDFCoverPages

Bender, E. M., & Koller, A. (2020). Climbing towards NLU: On Meaning, Form, and Understanding in the Age of Data. *Proceedings of the 58th Annual Meeting of the Association for Computational Linguistics*, 5185-5198. https://doi.org/10.18653/v1/2020.acl-main.463

Birtchnell, T. (2011). *Jugaad* as systemic risk and disruptive innovation in India. *Contemporary South Asia*, *19*(4), 357–372. https://doi.org/10.1080/09584935.2011.569702

Chen, X., & Cardie, C. (2018). Unsupervised Multilingual Word Embeddings. *Proceedings of the 2018 Conference on Empirical Methods in Natural Language Processing*, 261-270. https://doi.org/10.18653/v1/D18-1024

Desai, N. P., & Dabhi, V. K. (n.d.). *Taxonomic survey of Hindi Language NLP systems*. arXiv. https://doi.org/10.48550/arXiv.2102.00214

Deutscher, G. (2011). *Through the language glass : why the world looks different in other languages*. Picador.

Hershcovich, D., Frank, S., Lent, H., de Lhoneux, M., Abdou, M., Brandl, S., Bugliarello, E., Cabello Piqueras, L., Chalkidis, I., Cui, R., Fierro, C., Margatina, K., Rust, P., & Søgaard, A. (2022). Challenges and Strategies in Cross-Cultural NLP. *Proceedings of the 60th Annual Meeting of the Association for Computational Linguistics*, *1*, 6997-7013. https://doi.org/10.18653/v1/2022.acl-long.482

Hovy, D., & Spruit, S. L. (2016). The Social Impact of Natural Language Processing. *Proceedings of the 54th Annual Meeting of the Association for Computational Linguistics*, *2*, 591-598. https://doi.org/10.18653/v1/P16-2096

Jeffrey, C., & Young, S. (2013). Jugād: Youth and Enterprise in India. *Annals of the Association of American Geographers*, *104*(1), 182–195. https://doi.org/10.1080/00045608.2013.847757

Prabhu, J. (2017). Frugal innovation: doing more with less for more. *Philosophical Transactions of the Royal Society A*, *375*(2095). https://doi.org/10.1098/rsta.2016.0372

Prabhu, J., & Jain, S. (2015). Innovation and entrepreneurship in India: Understanding jugaad. *Asia Pacific Journal of Management*, *32*, 843-868. https://doi.org/10.1007/s10490-015-9445-9

Prahalad, C.K., & Mashelkar, R.A. (2010, August). *Innovation's Holy Grail*. Harvard Business Review. https://hbr.org/2010/07/innovations-holy-grail

Prakash, J., Chatterjee, K., Srivastava, K., & Chauhan, V. S. (2019). *Jugaad*: An indi-genius problem-solving approach. *Industrial psychiatry journal*, *28*(2), 312–314. https://doi.org/10.4103/ipj.ipj_87_20

Radjou, N. (2024, November 29). *Frugal innovation creates more economic and social value while using minimum resources*. Red Social Innovation. https://red-social-innovation.com/en/navi-radjou-frugal-innovation-creates-more-economic-and-social-value-while-using-minimum-resources/

Rangaswamy, N., & Densmore, M. (2013, December 7). Understanding Jugaad: ICTD and the tensions of appropriation, innovation and utility. *ICTD '13: Proceedings of the Sixth International Conference on Information and Communications Technologies and Development: Notes*, *2*, 120-123. https://doi.org/10.1145/2517899.2517938

Rao, S. (2016, December). *Book Review: GRASSROOTS INNOVATION: MINDS ON THE MARGIN ARE NOT MARGINAL MINDS*. Agricultural Extension in South Asia. https://www.aesanetwork.org/wp-content/uploads/2018/02/GRASSROOTS-INNOVATION-MINDS-ON-THE-MARGIN-ARE-NOT-MARGINAL-MINDS.pdf

Sambasivan, N., Kapania, S., Highfill, H., Akrong, D., Paritosh, P., & Aroyo, L. M. (2021). "Everyone wants to do the model work, not the data work": Data Cascades in High-Stakes AI. *CHI '21: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, 1-15. https://doi.org/10.1145/3411764.3445518

Sekhsaria, P. (2013). The making of an indigenous scanning tunneling microscope. *Current Science*, *104*(9), 1152–1158. http://www.jstor.org/stable/24092394

Sharma, A., & Iyer, G. R. (2012). Resource-constrained product development: Implications for green marketing and green supply chains. *Industrial Marketing Management*, *41*(4), 599-608. https://doi.org/10.1016/j.indmarman.2012.04.007

Varma, P. K. (2006). *Being Indian : inside the real India*. Arrow.