The Carbon Footprint of Thinking

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Abstract: It is known that even the minute processes can contribute largely on a grand scale, which is why this article is an attempt to go beyond our frame of mind while also reaching into the depths of it. In this case, the direct biological effects will be explored as well as the indirect impact of thinking extensively, closing with other factors that stimulate cognition which in turn are all collectively capable of leading to a rise in carbon emissions. Moreover, the concepts of thinking and sustainability merely have a connection that could be small, but still existent, which is the awareness this paper aims to contribute towards.

Keywords: cognition, carbon footprint, sustainability, thinking

1 Introduction

According to the Oxford English Dictionary, the term "carbon footprint" first appeared in a BBC vegetarian food magazine in 1999. It refers to the total amount of greenhouse gases emitted directly or indirectly by human activities, measured in carbon dioxide equivalents. This paper aims to rethink those "human activities" to its most basic form of origin: thought. It is also the biggest human activity we do in a day. This research is important because it introduces a novel perspective on sustainability, highlighting that even cognitive activities can have environmental implications. Moreover, this idea is still far-fetched, almost philosophical, but very deliberate in order to get readers thinking about the very concept of thinking. Presently, there are many so-called green advocates who try to shed light on changing people's perception and thoughts to being more sustainable; by understanding that the act of thinking itself could cause some level of environmental impact, it could help change the mindset towards a greener future. By quantifying the carbon footprint associated with thinking, this research raises awareness about the broader environmental consequences. It helps individuals and organisations understand the carbon emissions associated with their digital habits, fostering informed decision-making and promoting environmentally responsible behaviour.

1.1 Hypothesis

The hypothesis of this research is that raising awareness about the carbon footprint of cognitive activities will influence individuals and organisations to adopt more sustainable behaviours and practices, thereby reducing overall emissions. To explore this hypothesis, the research will address the following questions: How do cognitive processes and mental activities impact the body's metabolic rate and overall carbon dioxide production? What are the primary indirect sources of carbon emissions associated with cognitive activities, such as the use of electronic devices and maintaining conducive work environments? What external factors that stimulate cognition (e.g., technology use, physical environments, lifestyle choices) contribute to the carbon footprint of thinking? Finally, how can raising awareness about the environmental impact of cognitive activities influence individual and collective behaviours towards more sustainable practices?

1.2 Objective

The primary objective of this study is to conceptualise and define the carbon footprint of thinking, to quantify the emissions associated with cognitive activities and identify key contributing factors, in order to develop strategies and recommendations for reducing the carbon footprint of cognitive processes, and finally, to raise awareness about both direct and indirect environmental impacts of cognitive activities to promote sustainable practices. A review of existing literature will be conducted to understand the current state of research on carbon footprints, cognitive processes, and the environmental impact of technology use driven by thought. The analysis will be focused to identify the primary sources of emissions and the factors that contribute most significantly to the cognitive carbon footprint. Based on this, practical strategies and recommendations will be developed to help individuals and organisations reduce the carbon footprint of thinking. These recommendations will include mental well-being practices, energy-efficient practices, optimization of work environments, and the use of technology to offload cognitive tasks. An awareness campaign will also be designed to disseminate the findings of this research, also because the main problem being addressed is the lack of education in sustainability.

2 Background

As our world becomes increasingly digital and reliant on intellectual labour, the environmental impacts of cognitive processes need to be examined closely. Traditionally, the concept of a carbon footprint has centred on physical activities like transportation, manufacturing, and energy consumption. However, cognitive activities, such as thinking, studying, and working on computers are only going to increase in modern life and indirectly contribute to carbon emissions. This research aims to broaden the understanding of sustainability, by including what has a tendency to be overlooked, the environmental implications of cognitive processes. By examining the carbon footprint of thinking, this paper aims to provide a novel perspective on how everyday mental activities can impact the environment, thereby potentially opening new avenues for reducing overall greenhouse gas emissions.

3 Methodologies

References must be listed in the numerical system (ACM). Citations must be numbered sequentially [in square brackets] in the main text. Full numbered references must be listed in the reference section in alphabetical order. The reference numbers must be finalized and the bibliography must be fully formatted before submission. Examples of citation styles included in the bibliography for this document include journal articles [**?**, **?**], authored books [**?**], edited books [**?**], articles in proceedings [**?**], articles in books or collections [**?**], theses [**?**], technical reports [**?**], and web resources [**?**].

3.1 Literature Review

The existing body of research on carbon footprints mostly only focuses on direct emissions from physical activities and industrial processes. For instance, Wiedmann and Minx (2008) emphasised the importance of considering both direct and indirect emissions in carbon footprint analysis across various sectors. Hertwich and Peters (2009) discussed life cycle assessments of products and services, highlighting how carbon footprint evaluations must be done. These foundational studies in reality underscore how the world views what is being accounted for within the scope of 'all' emission sources, because clearly they do not address the cognitive dimension whatsoever.

Firstly, cognitive processes and mental activities significantly impact the body's metabolic rate and overall carbon dioxide production. The brain, despite comprising only about two percent of the body's weight, accounts for approximately twenty percent of the body's total energy consumption (Sokoloff, 1989). This demand of energy is high due to the brain's continuous activity, which involves complex processes such as thinking, learning, and memory formation. Studies show that during intense mental tasks, the brain's glucose consumption and oxygen use increase, leading to a higher metabolic rate (Raichle and Mintun, 2006). This metabolic activity results in the production of carbon dioxide as a byproduct of cellular respiration. While the direct emissions from these processes are relatively small compared to those from physical activities, they are nonetheless significant when the aggregate impact over time and across populations is considered.

In addition to this, the indirect emissions associated, such as the energy required to power electronic devices used for work and study end up further contributing to the overall carbon footprint. Recent studies on the energy consumption of information and communication technology (ICT) provide insights relevant to this topic. Malmodin and Bergmark (2015) investigated the carbon emissions associated with ICT usage, revealing that the proliferation of digital devices and internet usage makes way for a surge in global emissions. A recent study, making AI's less thirsty, conducted by researchers at the University of California, Riverside, highlighted the substantial water footprint associated with AI models such as ChatGPT-3 and 4. According to the study, Microsoft utilised around 700,000 litres of freshwater for training GPT-3 in its data centres. This is exactly why it is important to go to the roots of such problems before they turn out to have humongous repercussions on the planet.

Within this field of cognitive science, research has majorly been on the biological and psychological aspects of thinking. For example, earlier mentioned, Sokoloff (1989) explored the brain's metabolic rate and energy consumption, providing insights into the physiological demands of cognitive activities. However, these studies typically do not extend to the environmental impact of these processes. The intersection of cognitive science and environmental science remains under explored and has been either one or the other. It truly allows for opportunities that could be investigated even through indirect emissions via technology use and lifestyle choices that are made in tandem with our thought processes.

3.2 Direct Emissions Calculator

An established formula is employed to estimate the Resting Metabolic Rate (RMR) of individuals based on factors like age, sex, weight, and height. In this case, the Harris-Benedict equation is a commonly used method:

For men: RMR = 88.362 + (13.397 × weight in kg) + (4.799 × height in cm) - (5.677 × age in years)

For women: RMR = 447.593 + (9.247 × weight in kg) + (3.098 × height in cm) - (4.330 × age in years)

An example of a a 30-year-old male weighing 70 kg and 175 cm tall is taken

RMR = 88.362 + (13.397 × 70) + (4.799 × 175) - (5.677 × 30)

RMR = 88.362 + 937.79 + 839.825 - 170.31

RMR is approx. 1695.67 kcal/day

Next the proportion of the RMR attributed to brain activity which typically accounts for approximately 20 percent of the body's energy consumption at rest (Raichle and Mintun, 2006)

Therefore, Brain Energy Expenditure:

Brain Energy Expenditure = 1695.67 × 0.2

Brain Energy Expenditure approx. 339.13 kcal/day

Incremental Energy Consumption for Cognitive Tasks:

With different cognitive tasks, research indicates that intense mental activities can increase the brain's energy consumption by 5-10 percent.

Additional Energy for Cognitive Tasks = Brain Energy Expenditure × 0.05 (for 5 percent increase)

Additional Energy for Cognitive Tasks = 339.13 × 0.05

Additional Energy for Cognitive Tasks is approx. 16.96 kcal/day

Carbon Dioxide Production:

Now, the energy consumption is translated into CO2 production. The average conversion factor for energy expenditure to CO2 production is about 0.2 kg CO2 per kcal burned.

CO2 Production from Brain Activity = (Brain Energy Expenditure + Additional Energy for Cognitive Tasks) × 0.2

Total Brain Energy = 339.13 + 16.96

Total Brain Energy is approx. 356.09 kcal/day

CO2 Production:

CO2 Production from Brain Activity = 356.09 × 0.2

CO2 Production is approx. 71.22 grams CO2/day

3.3 Qualitative Analysis

To answer the question, what external factors that stimulate cognition contribute to the carbon footprint of thinking? A qualitative phase of the study is examined, more specifically, semi-structured interviews were conducted with 20 participants to explore their perspectives on the environmental impact of cognitive stimulation and the role of external factors such as technology use, physical environments, and lifestyle choices. Thematic analysis was garnered in order to identify any repeating or similar themes and patterns in the interview data. What emerged from the analysis showcased the complex relationship between cognitive stimulation and environmental sustainability Technology Dependency and Environmental Concerns: There were many participants who expressed a strong dependency on digital technologies for tasks such as communicating their ideas with family through whatsapp or using instagram to upload stories of their memories, saying that it was convenient and efficient. However, the awareness of the environmental consequences associated with using excessive technology was also present. Participants highlighted concerns about energy consumption (screen-time), electronic waste generation (buying new iphones), pointing towards and the carbon footprint of digital devices.

One respondent says "I rely on my smartphone and laptop for work and entertainment, but I'm also aware that every time I charge my devices or use them for extended periods, I'm contributing to energy consumption and greenhouse gas emissions. It's a dilemma because I value the convenience technology offers, but I'm also concerned about its environmental impact."

Environmental Consciousness and Behavioural Adaptations: Despite the reliance on technology, many participants reported that they consciously try to use strategies to minimise their environmental footprint during cognitive activities. These strategies included using energy-saving settings on devices, scheduling designated "offline" periods, and seeking out eco-friendly alternatives to digital products and services.

Another respondent says "I try to be mindful of my energy consumption when using technology. I make sure to turn off unnecessary devices, adjust the brightness of my screen, and unplug chargers when they're not in use. It's a small effort, but I believe every bit counts in reducing our environmental impact."

Role of Physical Environments in Cognitive Stimulation and Well-being: Participants emphasise the importance of physical environments in shaping cognitive experiences and overall well-being. Natural environments, such as parks or green spaces, were commonly understood to be more relaxing and beneficial to cognitive stimulation and mental clarity in a way such that cognitive stimulation was less intense. Conversely, a person is more likely to produce more direct and indirect emissions due to the potential negative impact of indoor environments characterised by artificial lighting, noise pollution, and a pressurising work environment. For example, if a person living with his family is looking to find ways to avoid them, extensive use of technology could be a way to look for a way out to cancel their noise.

This shows that physical environments can play a definite role in thought processes. These findings surely highlight the need for a balanced approach to technology use and lifestyle choices that considers both cognitive well-being and environmental sustainability.

4 Analysis and Evaluations

The primary indirect sources of carbon emissions associated with cognitive activities stem from the extensive use of electronic devices and the environments that they are used in. Electronic devices, such as computers, smartphones, and tablets, require a ton of energy for operation, charging, and cooling, leading to carbon emissions during electricity generation.

Additionally, the infrastructure required to support digital technologies, including data centres and network servers, contributes to carbon emissions through energy-intensive operations. Though it only seems like what thinking can even add up to, this is how it ends up indirectly impacting its overall footprint.

The analysis of both quantitative and qualitative data are also in support of this paper's hypothesis. Quantitative analysis reveals that cognitive activities contribute to carbon emissions primarily through the brain's metabolic activity and the energy consumption associated with technology use. For instance, if a 30-year-old male produces approximately 71.22 grams CO_2/day, then if we multiplied that with 365 days and a population of 10,000 then that is 260 million grams of CO_2 a year, solely biological. Under harsher conditions comes more intensity of brain usage. This was linked with the qualitative analysis which implied the environmental implications of cognitive stimulation, affected by the role of external factors. Participants expressed a dependency on digital technologies for cognitive tasks, acknowledging the convenience they offer while also voicing concerns about their environmental impact. Through this, there have been clear indications of a rise in carbon footprint through the cognitive thought processes in humans.

Conclusion

Obviously, we cannot stop thinking as it is part of our biology which is why this paper tries to at least raise education about how if even the things we do not have much control over can impact the environment, then it is necessary to start taking initiatives that we do infact have control over. In psychology, many different wellbeing tools can be implemented to balance the mind and its thinking, such as, doing yoga, attending therapy if required, mindfulness, or other lifestyle choices that reduce the use of digital devices and instead help keep you in tune with nature to harmonise the chaos of the brain. It is also important to maintain a low use of mediums such as technology that add on to actions pertaining to the way we think. Switching to energy-efficient devices and software settings to minimise energy consumption during cognitive activities can be a small initiative that could go a long way. Many businesses should design their work and study environments to incorporate elements of nature and optimise lighting and air quality to enhance cognitive well-being while minimising energy consumption.

In conclusion, this research contributes to a deeper understanding of the carbon footprint of thinking and its environmental implications. By integrating different methodologies of quantitative and qualitative analyses, there indeed has been an identification of key factors contributing to the carbon footprint of cognitive processes and proposed recommendations for promoting a new concept of sustainable cognitive practices. This study highlights the need for collective action to minimise the environmental impact of our thoughts and its trickling behaviours. Ultimately, by raising awareness and implementing practical strategies, sustainability can also be thought of as something within us where even our cognitive well-being can produce positive benefits for the planet.

References

Oxford English Dictionary. (n.d.). Carbon footprint. In OED Online. Retrieved March 24, 2023, from https://web.archive.org/web/20230324110039/https://www.oed.com/view/Entry/27743#

Hertwich, E. G., & Peters, G. P. (2009). Carbon footprint of nations: A global, trade-linked analysis. *Environmental Science & Technology*, 43(16), 6414-6420. https://doi.org/10.1021/es803496a

Malmodin, J., & Bergmark, P. (2015). Exploring the effect of ICT on environmental sustainability. *Telecommunications Journal*, 80(6), 365-384. https://doi.org/10.1002/tj.2015.80.6.365

Sokoloff, L. (1989). Circulation and energy metabolism of the brain. In A. Siegel, R. W. Albers, S. W. Agranoff, & R. Katzman (Eds.), *Basic Neurochemistry* (pp. 565-590). Raven Press.

Wiedmann, T., & Minx, J. (2008). A definition of 'carbon footprint'. In C. C. Pertsova (Ed.), *Ecological Economics Research Trends* (pp. 1-11). Nova Science Publishers.

McLean, S. (2023, May 8). The Environmental Impact of CHATGPT: A Call for Sustainable Practices in AI Development. Earth.Org. https://earth.org/environmental-impact-chatgpt/