Can AI take inspirations from dreams like us?

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***Abstract*—Many historical figures in both arts and sciences have taken inspirations from their dreams to pursue creative & impactful work. Most notoriously, the classic book *Frankenstein*, and the discovery of the chemical structure of Benzene, were all inspired by dreams. This gives arise to the exciting question: would it be possible to make AI systems dream like us, so they can also take creative inspirations from their dreams? More interestingly, are existing generative AI models *already* unintentionally adapting some of the biological processes happening in our brains when we dream? This paper approaches such questions by first reviewing the scientific literature that discuss about various biological phenomena that happen in our brains during REM sleep. Then, using these reviews as bases, this paper suggests that existing deep generative models, such as GANs, may already be unintentionally exhibiting one crucial attribute of the dreaming brain, namely the inactive prefrontal cortex. This paper further highlights that considering the behaviour of MCH neurons during REM sleep may be an important step in building an AI that can take creative inspirations from dreams just like us.**

I. Introduction

Sleep is composed of two stages, namely REM (Rapid Eye Movement) and non-REM [1]. We mostly dream during REM, and this cycle lasts around 2 hours per night [1]. While it may seem insignificant, this accumulates to 31 days per year! Despite spending 8% of our lives dreaming, we usually do not think of our dreams. One possible reason is that since our dreams did not happen in the real world, we do not find the need to put our energy and time analyzing them; after all, the events in our dreams will not act as causal agents in the real world. Our dreams being *weird* may contribute in further fuelling this perception. Because the dreams we have are often times ”illogical”, we may unconsciously further reinforce ourselves that dreams are irrelevant to our lives. How accurate is this belief? Are dreams really not useful to us?

II. Dreams and Creativity

While our dreams are composed of events that highly contradict our logic, they also allow us to have creative thoughts that we would otherwise never have. In fact, many artists and scientists have taken advantage of such extraordinary phenomenon to produce some of the greatest work in human history.

The classic book that everyone read in secondary school, *Frankenstein*, is one famous example [2]. A vivid dream that Molly Shelly, the author, had, became the basis of her book, and such simple event led to a remarkable story that explores deep philosophical themes such as free will, revenge, and man vs nature, from a unique perspective. *Frankenstein* is just one of many great literature that have been inspired by dreams; *Jane Eyre* by Charlotte Bronte, *The Metamorphosis* by Franz Kafka, and *The Strange Case of Doctor Jekyll and Mr. Hyde* by Robert Louis Stevenson are some of other instrumental books that have been inspired by dreams [2]. Other forms of art, such as paintings, have also utilized dreams; for example, the notable *The Nightmare* shown in Figure 1, is believed to be based on an obsessive dream that Henry Fuseli, the painter, had, about a young woman he was deeply in love with [3].

Fig. 1. a) *The Nightmare* by Henry Fuseli b) Chemical structure of Benzene

While it is extremely fascinating that dreams inspired brilliant art throughout history, what is even more extraordinary is that dreams have also made significant contributions in groundbreaking scientific discoveries. For example, the structure of Benzene, an essential chemical component for materials such as plastic and synthetic fibers, was discovered after chemist Friedrich August Kekule had a dream of a snake attacking its own tail; this odd vision of his allowed him to picture the ring structure of Benzene [4]. Furthermore, Otto Loewi, a biologist who won the 1903 Nobel Prize in Medicine for discovering that neurons communicate via chemical signals, stated that the experiment that led to such discovery was based on a highly non-trivial experiment he repeatedly had in his dreams [5]. These are only a few examples; other disruptive scientific achievements such as Neil Bohr’s theory of orbital structure of atoms, Alfred Russel Wallace’s theory of evolution by natural selection, and Srinivasa Ramanujan’s various discoveries in number theory, were all greatly inspired by their dreams [6].

As such prolific figures have demonstrated, dreams can be *sources* of immense creativity in our work. This gives arise to an exciting question: how can we make AI systems *adapt* the process of human dreaming so they can also discover extremely creative ideas? Moreover, are some existing AI systems *already* imitating our dreaming to produce remarkably creative visualizations? To approach such questions, we first review the neurological processes that happen when we dream.

III. Biology of Dreaming

As mentioned, we mostly dream during the REM cycle. Thus, understanding what's happening in our brains when we dream, means understanding what's happening in our brains during the REM cycle. During our REM sleep, the neurons in the prefrontal cortex become significantly deactivated compared to when we are awake [7]. According to many studies, such as [8,9,10], the prefrontal cortex is most responsible for our logic and reasoning abilities. Thus, when the prefrontal cortex becomes deactivated, our logic and reasoning system becomes disoriented as a consequence. In addition to the change in our prefrontal cortex, a region in the medial temporal lobe called amygdala becomes more active [11]. It is well known in the neuroscience community that amygdala is responsible for processing & producing distressing emotions like anxiety and fear [12]. Thus, amygdala being more active during REM sleep indicates that uneasy and frightful feelings are enhanced while we dream. Interestingly, researchers in the psychology community have found that there is a correlation between the degree of anxiety and the level of creativity [13]. Thus, it is very possible that intensified anxiety and fear stemming from increased amygdala activity contribute to the exceptionally creative thoughts we have in our dreams. Finally, melanin concentrating hormone (MCH) neurons, which are usually off, including during non-REM sleep, turns on during REM sleep [14]. Research have shown that MCH neurons are responsible for helping brain forget information [14]. Thus, as elaborated by Kilduff in [14], it is plausible that the turned-on MCH neurons during our REM sleep prevents us from being able to retain & recall majority of our dreams. Furthermore, other processes such as significant lack of norepinephrine, which are hormones that help enhance one's memory, could also contribute to us having difficulty recalling our dreams [15,16].

IV. AI That Dream Like Us

When awake, we primarily envision images that appear like ”things” we witnessed in the real world. In contrast, deep generative models, such as generative adversarial networks (GANs), not only envision images that appear like those they have been trained on, but also frequently images that appear *far different* than the individual images in the training dataset. For example, even though we look at almost equal amounts of people and animals (eg. dogs, birds, squirrels, etc) everyday, we rarely visualize an image that is the hybrid of a person and an animal. In contrast to this, if one trains GAN on a dataset containing images of people and animals, it can generate images that look like people and animals, respectively, but also easily images that are the combination of both. However, it is important to acknowledge that when we dream, we commonly envision both precedented *and* unprecedented images, just like GANs. In another words, deep generative models, such as GANs, are already exhibiting the behavior of our minds when we dream. Could this phenomenon be explained in terms of the neurological processes discussed? When awake, it seems that we often limit our thoughts based on what's possible in the real world. Such restrictions would likely have been constructed through our countless positive & negative experiences and observations in the real world. In comparison, it seems that deep generative models have no restrictions on their thoughts, and this could be because unlike us, they have no “reference” world that they can interact with & attain such constraints from. As discussed in section III, when we dream, our prefrontal cortex, which is responsible for our reasoning abilities, turns off. Note that, as elaborated by Funk in [17], our understanding of the real world is the basis of our reasoning abilities. Therefore, when our prefrontal cortex is off, and consequently, our reasoning abilities are off, it is possible that the constraints that were placed in our minds *due* to the understanding we have of the real world, are also dimmed. In another words, when we dream, it is possible that the presence of our “reference” world, ie. the real world, becomes vastly less significant similar to deep generative models, and such phenomenon may allow us to imagine like deep generative models when we dream. In essence, this hypothesis states that the possible lack of deep generative models' access to any “reference” world, and the absence of reasoning abilities stemming from it, could be an emulation of what happens to us when we dream due to our inactive prefrontal cortex, and deep generative models unintentionally adapting such biological process can be a potential reason as to why they are capable of outputting extremely creative visualizations, similar to when we dream.

Fig. 2. Left image has been produced by a transformer-based generative model called Dall-E (OpenAI). Right image has been processed by GAN, which seamlessly merged Van Gogh's *Starry Night* with Toronto's skyline.

To the best of our knowledge, no existing work aimed to directly adapt the biological processes of dreaming to deep generative models, although existing deep generative models may already be unintentionally exhibiting such processes as previously discussed. GANs and diffusion models, like Dall-E, produce remarkable ”dream-like” visualizations as shown in Figure 2, but these architectures have been inspired by ideas in fields distant from biology, such as classical game theory and non-equilibrium thermodynamics [18,19]. If we were to create a new deep learning architecture that allows AI to *truly* dream like us, incorporating all of the major biological processes discussed in section III may be needed. Some regions of the brain that play critical roles in our dreaming, such as the prefrontal cortex and amygdala, have consistently drawn attention of the AI community, and researchers at large academic & industrial labs such as MILA and DeepMind have recently started to study them extensively [20,21,22]. However, to the best of our knowledge, the activities of MCH neurons, and their influence in memory retention, have not yet been explored in the context of artificial intelligence.

Extremely interesting theory by Hoel states that from an abstract perspective, the reason for dreaming is to prevent our brains from overfitting the data we obtained throughout the day [23]. In another words, in order to prevent us from simply memorizing the data we encountered in the real world, and instead help us extract generalizable patterns from these data, our brains create an "outlier" dataset that consists of highly nonsensical visualizations. However, it is important to emphasize that creating astounding visualizations, which is where most of the attention has been in both the neuroscience and AI communities, is just one component of our dreaming; our dreaming also has a *filtering* process, that selects only a *subset* of all of the visualizations created, which we can remember after awaking. These dreams, ie. the dreams that we are able to remember after awaking, are of course the only dreams that are relevant to us & that we *could* use as sources of creativity for our work. Thus, if we want to build an AI that can take creative inspirations from dreams *truly* like us, we cannot simply aim to understand how to build a generative model which outputs a nonsensical dataset that is the most optimal for preventing overfit of some pertinent dataset; instead, we also need to aim to have a deep understanding as to why *certain* visualizations from the nonsensical dataset decide to continue to stay with us even after awaking, so that we could incorporate such data-selection process to AI. Now, we know that MCH neurons during REM sleep primarily influence episodic memories, which are memories that contain information about the times and locations certain memories were acquired [24]. Unfortunately however, it is still unclear under which criteria or metrics MCH neurons "choose" what memories to remove & keep during REM sleep, and this makes it difficult to accurately integrate such phenomenon in AI. Even though the underlying process is unknown, there seems to be some patterns to which types of dream are more prone to passing the filter; for example, studies have shown that dreams that are emotionally triggering, such as nightmares, tend to more-commonly stay with us [25]. As previously discussed, distressing feelings are processed & produced by amygdala. Thus, like with mood-related behaviours [26], it is possible that there is an association between the activities of amygdala and MCH neurons in regulating memories during REM sleep, and we strongly encourage the neuroscience community to further investigate their potential relationship in the future.

V. Conclusion

This paper discussed about the remarkable cases in which people took inspirations from their dreams to do groundbreaking work in their fields. To examine the possibility of making AI systems also dream like us, as well as if any existing generative AI models are already exhibiting such processes, biological phenomena that happen in our brains during REM sleep were first studied. Using these scientific literature as support, this paper proposed that generative AI models, such as GANs, may already be unintentionally mimicking our inactive frontal cortex in order to produce extremely creative visualizations. Furthermore, this paper elaborated that the filtering process of dreaming is just as important as the visualization component of dreaming in giving us creative inspirations, and thus there should be more attention in better understanding the behaviour of MCH neurons from both the AI and neuroscience research communities.

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