Symbiotic Co-Creation with AI

Ninon Lizé Masclef [1]

Abstract

The quest for symbiotic co-creation between humans and artificial intelligence (AI) has received considerable attention in recent years. This paper explores the challenges and opportunities associated with human-AI interaction, focusing on the unique qualities that distinguish symbiotic interactions from conventional human-to-tool relationships. The role of representation learning and multimodal models in enabling symbiotic co-creation is discussed, emphasising their potential to overcome the limitations of language and tap into deeper layers of symbolic representation. In addition, the concept of AI as design material is explored, highlighting how the latent spatial representation of generative models becomes a field of possibilities for human creators. It also explores novel creative affordances of AI interfaces, including combinational, exploratory and transformational creativity. The paper concludes by highlighting the transformative potential of AI in enhancing human creativity and shaping new frontiers of collaborative creation.

1. Introduction

As our interactions with AI continue to evolve, a parallel development has emerged in the form of an interdisciplinary research field known as Human-AI Interaction, as proposed by Capel and Brereton (Capel & Brereton, 2023). This field recognizes the urgent need to explore the dynamics, challenges and opportunities associated with human-AI collaboration.

The nature of the relationship between humans and AI has been at the centre of recent discussions, particularly during the CHI 2023 conference. The tension between viewing AI as a mere tool or as a collaborator has sparked intense debate within the HCI community. These discussions have also led to critical reflections on the notion of 'human-AI collaboration' (Sarkar, 2023) and the need to define the specific nature of the partnership, highlighting the importance of understanding and delineating the human-AI relationship in the context of co-creation.

1.1. Human-AI Symbiosis

In *Man-Computer Symbiosis*, Licklider predicted that humans and computers would form a symbiotic relationship, defined as the cooperative co-existence of two biologically distinct species in close association or even intimate interaction (Licklider, 1960). However, achieving symbiotic relationships with AI goes beyond the mere externalisation of human functions as prosthetics. Licklider's concept of symbiosis goes beyond the notion of AI as a "mechanically extended arm" or "humanly extended machines" (Licklider, 1960). It requires a deeper understanding and exploration of the unique qualities that distinguish symbiotic interactions from conventional human-to-tool relationships.

By considering the unique challenges and opportunities inherent in the symbiotic interaction between humans and AI, researchers and practitioners in the field of human-AI interaction aim to navigate the intricacies of this relationship, enable fruitful collaboration, and advance our understanding of how humans and AI can co-create in transformative ways.

1.2. The Language Problem

> The basic dissimilarity between human languages and computer languages may be the most serious obstacle to true symbiosis.
>
> (Licklider, 1960)

Licklider emphasised the need to develop natural means of communication to overcome the significant language barrier between humans and computers, which is a major obstacle to achieving a symbiosis between the two. What distinguishes man from other species is the peculiarity of being a *symbolic animal* (Cassirer, 1944). While language serves as a set of instructions for computer systems, it carries a *symbolic action* for humans, enabling the expression of goals, intentions and more (Burke, 1966). This fundamental difference in the nature of language can be encapsulated

[1]Dassault Systèmes, Vélizy-Villacoublay, France. Correspondence to: Ninon Lizé Masclef <contact@ninonlizemasclef.com>.

AI & HCI Workshop at the 40^{th} International Conference on Machine Learning, Honolulu, Hawaii, USA. 2023.

in the Two Black Box problem, where on the one hand modelling of human behaviour (XCI) is required, and on the other hand explainability (XAI) is crucial (Wenskovitch, 2020; Li & Hilliges, 2021).

2. Learning a representation

The linguistic aspect of symbiosis highlights the importance of a shared language of cooperation that operates at the symbolic level, facilitating the production of knowledge representations and shaping our model of the world (Whorf, 1940). This aspect falls within the domain of representation learning, which explores how language representations contribute to our understanding of the world.

Today, many machine learning models use publicly available data from the Internet to train on large amounts of information. One notable example is OpenAI's Contrastive Language-Image Pre-training (CLIP) (Radford et al., 2021), which aims to make connections between images and their textual descriptions, ultimately developing a comprehensive abstraction of human knowledge. CLIP and similar models excel at compressing diverse data domains while maintaining a high degree of generality. They form the basis of many generative projects, such as Text2Mesh (Michel et al., 2021), ClipMatrix (Jetchev, 2021), and Dream Field (Jain et al., 2022), which allow the generation of 3D shapes from textual instructions. In addition, models such as MuLan (Huang et al., 2022) have emerged that focus on learning representations of text-audio pairs. Such models have been used to generate music using MusicLM (Agostinelli et al., 2023).

However, there are cases where words alone may not be sufficient to adequately represent certain concepts or experiences, as some things are inherently unspeakable. For instance, R. Picard predicted that computers might be able to to recognize patterns of behaviour for which we may not have have expressions for, such as unique affective states and moods specific to a given user (Picard, 1997). In such cases, self-supervised learning (SSL) (Jing & Tian, 2019) techniques offer a promising solution. SSL allows models to learn from unlabelled data, relying on the inherent structure or relationships in the data itself. Using SSL, models can extract meaningful patterns, associations and representations without relying on explicit labels, allowing them to capture nuanced aspects of the data that may not be easily captured by explicit supervision.

In addition, the integration of multimodal models provides a route to a richer symbolic representation. Using multiple modalities such as text, images, audio and more, these models can capture a richer understanding of the world and its complexities. By exploiting the synergy between different modalities, multimodal models offer a broader and more expressive means of representation and co-creation with AI. Recent examples of multimodal interfaces that enable co-creation with AI include a multimodal prompt interface for visual design space exploration (Liu, 2023) and a creative writing support interface that provides textual, visual and auditory writing suggestions (Singh et al., 2022b). This multimodal approach allows the exploration of creative possibilities beyond the constraints of individual modalities, enabling the generation of novel and immersive experiences that transcend linguistic boundaries.

By incorporating self-supervised learning and multimodal models into the framework of human-AI co-creation, we can overcome the limitations of language and tap into the deeper layers of symbolic representation. These approaches offer opportunities to capture the ineffable, to exploit unlabelled data, and to unleash the creative potential that arises when different modalities converge. In the following sections, we will explore the significance of self-supervised learning and multimodal models in the context of human-AI co-creativity, exploring their potential to enhance the symbiotic relationship between humans and AI and to foster new frontiers of collaborative creation.

3. AI as a creative material

Once representation is learned, it becomes a powerful tool for human creators, akin to a design material (Dove et al., 2017). Particularly, the latent space representation of generative models becomes a field of possibilities, offering a infinite variations (Hui, 2023) that open the door to new forms of collaboration with AI. In this symbiotic relationship, the data set serves as the sculptor's clay, providing a malleable medium for creative expression (Moulon, 2021).

The evolution of the human brain and language, as proposed by Deacon (1998), enabled the creation of symbols, which in turn facilitated the development of intuitive and associative mental processes (Deacon, 1998). These meaningful connections across domains, including analogies and metaphors, form the basis of human creativity (Mithen, 1999). When assessing creativity, two different types of thinking are often identified: convergent and divergent thinking. Convergent thinking relies on data and logic to arrive at a single solution to a problem (Guilford, 1950), emphasising a single correct answer. In contrast, divergent thinking encompasses a framework that encourages the generation of a variety of ideas in response to a given question or stimulus (Dietrich, 2015).

The ideation stage of the creative process is a trial-and-error loop that mobilises both divergent and convergent thinking in complementary ways (Kaufman & Sternberg, 2019; Esling & Devis, 2020). However, there is no consensus on whether text-based interfaces designed for AI creativity promote one cognitive strategy over another. In particular, Davis et al. (Davis et al., 2023) showed that prompts work better as convergent than divergent support, while (Liu et al., 2022) found evidence that prompt suggestions containing emotional tone tend to lead participants in a divergent direction. Singh et al. (Singh et al., 2022b) provided a comprehensive overview of the cognitive strategies involved in creative writing with AI, revolving around the concept of the *integrative leap*.

4. Creative affordances for AI interfaces

Margaret Boden (Boden, 1998) claims there are three main ways in which new, unexpected and socially significant ideas can be discovered: combinational (by creating novel arrangements of familiar materials), exploratory (by finding new routes through conceptual spaces), or transformational (when the space itself is disturbed, allowing previously unthinkable ideas to emerge). As a result, there may be some undiscovered processes that promote AI creativity by enhancing its decision-making capabilities.

Combinational: When interacting with a generative model via text input (Brown et al., 2020; Liu & Chilton, 2022; Michel et al., 2021; Jain et al., 2022; Jetchev, 2021; Agostinelli et al., 2023), prompt engineering can be seen as a form of combinational creativity, in line with Boden's framework.

Finding the right set of words to express a novel idea involves carefully crafting or modifying input prompts to produce desired outputs or to guide the model's responses. For example, the prompt ”avocado chair” is a word combination that combines two concepts, both familiar to the user, but not commonly paired, to create a novel idea. This is very reminiscent of the collages and *exquisite corpses* practised by the Surrealists as a means of creating poetic associations, such as the famous ”as beautiful as the chance meeting of a sewing machine and an umbrella on an operating table” by Isidore Ducasse (Ducasse, 2011). An analogy between such word combinations and sketching exercises has been drawn in the creative ideation process of coming up with a new idea (Kim & Jung, 2023).

At the combinational level of creativity, the focus is on recombining and rearranging existing ideas, concepts or elements to create something new. Similarly, prompt engineering involves manipulating the input to guide the model's creative output, often by changing the wording, structure or context of the prompt. Liu and Chiton (Liu & Chilton, 2022) explored short prompts that combine themes and styles, and provided comprehensive prompt engineering guidelines for text-to-image generation. By using such prompt engineering techniques, users can leverage the capabilities of language models to produce creative output within the boundaries defined by the prompt. It involves using the existing knowledge and capabilities of the model in innovative ways, resulting in novel combinations or arrangements of information.

It is worth noting, however, that prompt engineering operates primarily within the constraints of the existing knowledge of the underlying model. Boden emphasised (Boden, 1998) the familiarity with the input material of creative combinaison. This suggests that, in the case of prompts, combinations are constructed from the user's common sense, i.e. the user's understanding of the words. Wang et al. (Wang et al., 2023) highlighted the discrepancies between humans and AI in understanding the meaning of prompts, especially in the case of emotionally charged descriptions. They showed that explanatory AI could benefit prompt design. Furthermore, Singh (Singh et al., 2022a) suggested replacing text prompts with slot prompts for compositional image generation.

Exploratory: Margaret Boden's exploratory level of creativity involves generating variations, making small changes, and exploring alternative paths to discover new ideas. In the context of AI models, Variational Autoencoders (VAEs) and Generative Adversarial Networks (GANs) afford this exploratory mode of interaction. These AI models incorporate mechanisms for exploration and variation, allowing them to generate new and diverse outcomes, discover novel solutions, or explore alternative paths. Using techniques such as random sampling, latent space manipulation, policy exploration, or genetic operators, these models can exhibit behaviour consistent with Boden's exploratory level of creativity. In particular, latent space cartography, introduced by Yang et al (Liu et al., 2019), used dimensionality reduction as a means of providing an exploratory tool for the latent design space of generative AI models. (Liu et al., 2019). In Aesthetics of Neural Network Art (Hertzmann, 2019), Hertzmann outlines the emergence of a practice among AI artists that consists of exploring latent space and experimenting with different z-vector generation to produce novel visuals. For example, Refik Anadol's Machine Hallucination (2019) is a video work that navigates through the latent space of a Generative Adversarial Networks (GAN) representing the photographic memory of New York City. Anadol coined the term *latent cinema* (Kivrak, 2020) to describe this space walk through the memories of AI models, drawing a parallel between this type of interaction and cinematic techniques.

Overall, a growing number of interfaces are being developed based on these latent spacewalks, making them a promising new mode of human-AI interaction used by both artists and designers (Davis et al., 2023; Wan & Lu, 2023; Ford & Bryan-Kinns, 2022).

Transformational: In terms of the transformational level of creativity, style transfer models and deepfakes exemplify this notion because they involve reshaping, modifying, or transferring the characteristics of one domain to another. Recently, deepfakes have benefited from a growing interest in human-AI interaction (Lizé Masclef & Reed, 2023; Danry et al., 2022).

In audio, deepfakes and timbre transfer techniques involve reshaping or transforming the audio characteristics of a source signal to match the timbre or style of another signal, resulting in novel and transformative outputs.

Using timbre transfer techniques, it is possible to change the sonic characteristics or style of one audio source to more closely resemble another. By altering the underlying characteristics of sound, this approach goes beyond conventional audio editing and enables the creation of innovative audio outputs. For example, timbre transfer can be used to change a human voice to match the timbre or style of a particular musical instrument, creating unique and innovative audio effects. In the music domain, the Realtime Audio Variational autoEncoder (RAVE) (Caillon & Esling, 2021) introduced a new generation of human-AI co-creation interfaces based on real-time neural audio style transfer.

Audio deepfakes (Khanjani et al., 2023), in which audio content is synthesised or modified to imitate a particular voice or generate speech that mimics a particular person's style, have also attracted attention. While deepfakes raise ethical concerns, they illustrate the transformative potential of AI in audio manipulation and speech synthesis.

5. Inputs: Symbols Beyond Prompt

> The hope is that, in not too many years, human brains and computing machines will be coupled together very tightly, and that the resulting partnership will think as no human brain has ever thought and process data in a way not approached by the information-handling machines we know today.
>
> (Licklider, 1960)

Licklider stated that human-computer symbiosis requires a close coupling between the two entities (Licklider, 1960). While the author proposed speech-based interaction as a means to achieve symbiosis, today there are other types of interfaces that are alternatives to this logocentric turn. Among them, Tangible User Interfaces (TUIs) and Brain-Computer Interfaces (BCI) are examined, which address the lack of embodiment and seamless communication with AI systems, respectively.

5.1. Tangible Interfaces

Touch is a sense that has recently and historically been neglected in comparison to vision. Yet touch is crucial for manipulating tools and craftsmanship. Since the pandemic lockdowns, we have observed an urge for physical contact, a "touch hunger" (Durkin et al., 2021). Smart materials have provided rich potentials for the embodiment of computational systems. In maker communities, the tactility of the material is what fosters an intimate relationship during the crafting process (Jones et al., 2023). Furthermore, the physicalization of AI through tangible artifacts offers new possibilities for embodied explainability. For instance, Mika Satomi created a wearable neural network garment, *Artificial Intelligence and Its False Lies* (2020), which displays the synaptic connections in real time as the model learns the user's movements with embroidered optical fibers.

Figure 1. Latent Organism. 2021-2022. Whole-body interface to navigate in the latent space of a text-to-mesh model. Pressure sensor matrix embedded in a soft controller affords both exploratory and combinational modes of interaction.

Latent Organism (2021-2022) (Lizé Masclef & Chuttarsing, 2023a;b) is a tangible interface enabling individuals to co-create 3D shapes with generative AI. The AI controller is composed of e-textile pressure matrix embedded in an embroidery that covers a bean bag chair. Leveraging a text-to-mesh model, Dream Field (Jain et al., 2022), it enables anyone to produce unique and complex 3D shapes through natural and playful interactions with an intuitive and sensitive tactile interface. The prompts are automatically generated with a word embedding model trained on the Encyclopedia of Life (eol.org) according to the way the user interacts with the physical interface. The interface learns and adapts to the user's preference while maintaining a sense of serendipity in the creative output, by randomly sampling the embedding model at specific interval.

The artifact is precisely aimed at overcoming the lack of embodiment of human-AI interaction. Instead of being a black box, the generative AI system of *Latent Organism* is incarnated in a soft, richly afforded material. The system looks alive and embodied (Fishkin, 2004), as if the AI system were inside this malleable artifact. Gradually, individuals are empowered to use the machine's imagination as a sculptable material. They begin to understand and control the creative output through physical exploration, which is difficult with most AI systems that are opaque to the user. Through the sensitivity of touch, they develop a new expertise – craftsmanship – of artificial imagination modelling.

5.2. Brain-Computer Interfaces

As state-of-the-art brain decoding evolves from invasive techniques such as electrocorticography (ECoG) to non-invasive methods such as electroencephalography (EEG), it will offer growing potential for human-AI interaction (Banville, 2022). While it is technically possible to decode speech from brain activity using invasive BCI, there is no consumer-ready technology yet. Just as speech decoding was not concretized at the time of the writing of *Man-Computer Symbiosis*, there is still a time gap before language decoding from brain activity becomes a stable technology integrated into everyday life. However, this does not mean that researchers cannot think about the future of human-AI interactions in terms of the future possibilities such an advancement would provide, following a speculative design approach. In particular, brain-AI interactions in a co-creative context are relevant in the areas of visual imagery, language decoding, and anticipatory response.

Recently, diffusion models have been used to reconstruct visual perception from brain activity (Chen et al., 2022; Takagi & Nishimoto, 2022; Ozcelik & VanRullen, 2023). In addition, several studies have shown that providing a decoded text label improves the semantic fidelity of reconstructing visuals from brain activity (Fang et al., 2020; Lin et al., 2022; Takagi, 2023). While visual perception and imagination are different, there is evidence that their representation in the brain overlaps, and examples of successful reconstruction of mental imagery from brain activity (Horikawa et al., 2013; Shen et al., 2019; Senden et al., 2019).

Artists have already used this reconstruction technique to create an interplay between human and artificial imagination. Pierre Huyghe's *UUmwelt* (2018), for example, relies on a GAN to reconstruct a person's mental images from their brain activity recorded with an fMRI scanner. Despite the poor visual quality of early GANs, this project exemplifies a new kind of human-AI interaction that uses neural interfaces to create hybrid imaginaries.

Inspired by ancient traditions of oneirocritics that view dream content as structured by rebus or wordplay, the ongoing artistic research project entitled *ReaDream* focuses on decoding the linguistic representations of dreams in the brain. With the aid of recent text-to-mesh generative models such as ClipMatrix (Jetchev, 2021) and DreamFusion (Poole et al., 2022), *ReaDream* generates immersive VR scenes based on the semantic features extracted from EEG signals of individuals during dreaming states. Figure2 displays the first prototype of the project that consisted in generating 2D paintings with diffusion models from semantic categories extracted from the brain activity of sleeping participants.

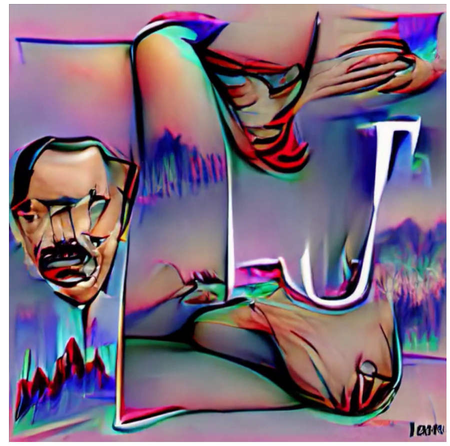

Figure 2. Dream painting generated from semantic features extracted from EEG signal during sleep

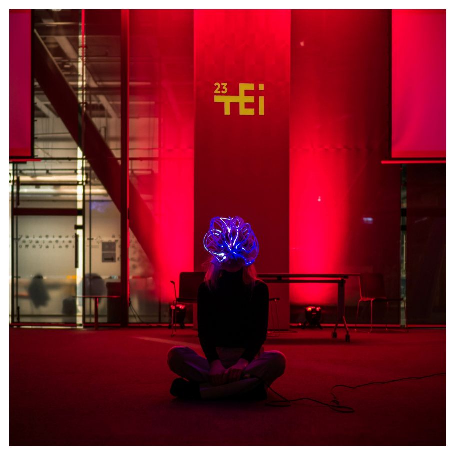

Figure 3. Multimodal performance leveraging brain-computer interface to control generative music models, and lights with emotional states

Another project, entitled *Strange Loops* (Lizé Masclef, 2023) is a multimodal performance composed of generative music and visuals controlled by brainwaves. The whole body of the performer is involved in the interaction with AI.

6. Workshop interest

During this workshop, I would like to discuss the nature of the relationship between humans and AI in the context of co-creation, leading optimally to a framework that encompasses behavioural modelling, inputs and affordances of AI interfaces. I am particularly interested in cognitive frameworks that underpin human-AI co-creation. In addition, I currently have a paper under review on my practice-based research on co-creation with AI to illustrate the search for more symbiotic modes of interaction. I would like to share insights on Lickider's concept of symbiosis in relation to rethinking the relationship with AI.

7. Conclusion

In the pursuit of symbiotic co-creation with AI, this paper has explored key aspects that contribute to fostering fruitful collaborations and advancing our understanding of human-AI interaction. The exploration of representation learning and multimodal models has demonstrated their potential to overcome the language barrier and enable the creation of richer symbolic representations. By integrating self-supervised learning and multimodal approaches, AI becomes a powerful tool for capturing the ineffable and tapping into deeper layers of meaning. Moreover, considering AI as a design material opens up new possibilities for human creators, enabling them to explore the vast design space and extend their creative processes. Exploring the new creative possibilities of AI interfaces has demonstrated the potential for combinational, exploratory and transformative creativity, further pushing the boundaries of human-AI collaboration.

As the field of human-AI interaction continues to evolve, it is important to recognize the nuanced nature of symbiotic relationships and explore the diverse ways in which humans and AI can co-create. Future research should focus on addressing the ethical and societal implications of symbiotic co-creation, ensuring transparency, fairness and accountability in AI systems. In addition, efforts should be made to equip individuals with the necessary skills and knowledge to collaborate effectively with AI, promoting inclusive and accessible co-creation processes. By fostering symbiotic relationships with AI, we can unlock new frontiers of creativity, enhance problem-solving capabilities, and shape a future where humans and AI work together in transformative ways.

Acknowledgements

I would like to thank my collaborators on the project *Latent Organism*: Adrien Chuttarsing, Marianne Canu and Sophie Chen. This interface was developed during the creARTathon workshop organised by Inria, the University of Paris-Saclay and the association Societies and supported by the French Ministry of Culture. The second iteration of the artwork was created for the Extended Senses & Embodying Technology Symposium 2022, supported by the X10DD Senses Laboratory research group at the University for the Creative Arts and the School of Design at the University of Greenwich, London. I would like to thank Taisija Demchenko for her collaborative work on several brain-computer interfaces, including the ongoing *reaDream* project. I am indebted to the co-authors of the *Dream Painting* project: Esther Senneker, Valentina Gambo, Andreas Knoben, Beyza Nur Çay, Gwendolyn van der Bie.

I am thankful to Dassault Systèmes for the funding of my artistic work. Lastly, I am extremely grateful to Women In Machine Learning for supporting my attendance at ICML.

References

Agostinelli, A., Denk, T. I., Borsos, Z., Engel, J., Verzetti, M., Caillon, A., Huang, Q., Jansen, A., Roberts, A., Tagliasacchi, M., Sharifi, M., Zeghidour, N., and Frank, C. MusicLM: Generating Music From Text, January 2023. URL http://arxiv.org/abs/2301.11325. arXiv:2301.11325 [cs, eess].

Banville, H. *Enabling real-world EEG applications with deep learning*. These de doctorat, université Paris-Saclay, January 2022. URL https://www.theses.fr/2022UPASG005.

Boden, M. A. Creativity and artificial intelligence. *Artificial Intelligence*, 103(1):347–356, August 1998. ISSN 0004-3702. doi: 10.1016/S0004-3702(98)00055-1. URL https://www.sciencedirect.com/science/article/pii/S0004370298000551.

Brown, T. B., Mann, B., Ryder, N., Subbiah, M., Kaplan, J., Dhariwal, P., Neelakantan, A., Shyam, P., Sastry, G., Askell, A., Agarwal, S., Herbert-Voss, A., Krueger, G., Henighan, T., Child, R., Ramesh, A., Ziegler, D. M., Wu, J., Winter, C., Hesse, C., Chen, M., Sigler, E., Litwin, M., Gray, S., Chess, B., Clark, J., Berner, C., McCandlish, S., Radford, A., Sutskever, I., and Amodei, D. Language Models are Few-Shot Learners, July 2020. URL http://arxiv.org/abs/2005.14165. arXiv:2005.14165 [cs].

Burke, K. Language as Symbolic Action: Essays on Life, Literature, and Method. December 1966. doi: 10.1525/9780520340664. URL https://www.degruyter.com/document/doi/10.1525/9780520340664/html. ISBN: 9780520340664 Publisher: University of California Press.

Caillon, A. and Esling, P. RAVE: A variational autoencoder for fast and high-quality neural audio synthesis, December 2021. URL http://arxiv.org/abs/2111.05011. arXiv:2111.05011 [cs, eess].

Capel, T. and Brereton, M. What is Human-Centered about Human-Centered AI? A Map of the Research Landscape. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, pp. 1–23, Hamburg Germany, April 2023. ACM. ISBN 978-1-4503-9421-5. doi: 10.1145/3544548.3580959. URL https://dl.acm.org/doi/10.1145/3544548.3580959.

Cassirer, E. *An Essay on Man: An Introduction to a Philosophy of Human Culture*. New Haven: Yale University Press, 1944.

Chen, Z., Qing, J., Xiang, T., Yue, W. L., and Zhou, J. H. Seeing Beyond the Brain: Conditional Diffusion Model with Sparse Masked Modeling for Vision Decoding, November 2022. URL http://arxiv.org/abs/2211.06956. arXiv:2211.06956 [cs].

Danry, V., Leong, J., Pataranutaporn, P., Tandon, P., Liu, Y., Shilkrot, R., Punpongsanon, P., Weissman, T., Maes, P., and Sra, M. AI-Generated Characters: Putting Deepfakes to Good Use. In *Extended Abstracts of the 2022 CHI Conference on Human Factors in Computing Systems*, CHI EA '22, pp. 1–5, New York, NY, USA, 2022. Association for Computing Machinery. ISBN 978-1-4503-9156-6. doi: 10.1145/3491101.3503736. URL https://doi.org/10.1145/3491101.3503736.

Davis, R. L., Wambsganss, T., Jiang, W., Kim, K. G., Käser, T., and Dillenbourg, P. Fashioning the Future: Unlocking the Creative Potential of Deep Generative Models for Design Space Exploration. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*, CHI EA '23, pp. 1–9, New York, NY, USA, 2023. Association for Computing Machinery. ISBN 978-1-4503-9422-2. doi: 10.1145/3544549.3585644. URL https://dl.acm.org/doi/10.1145/3544549.3585644.

Deacon, T. W. *The symbolic species: the co-evolution of language and the brain*. Norton, New York, NY, 1. publ. as a norton paperback edition, 1998. ISBN 978-0-393-31754-1 978-0-393-03838-5.

Dietrich, A. *How creativity happens in the brain*. Palgrave Macmillan, Houndmills, Basingstoke, Hampshire ; New York, NY, 2015. ISBN 978-1-137-50179-0.

Dove, G., Halskov, K., Forlizzi, J., and Zimmerman, J. UX Design Innovation: Challenges for Working with Machine Learning as a Design Material. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, CHI '17, pp. 278–288, New York, NY, USA, 2017. Association for Computing Machinery. ISBN 978-1-4503-4655-9. doi: 10.1145/3025453.3025739. URL https://doi.org/10.1145/3025453.3025739.

Ducasse, I. *The Songs of Maldoror*. University of chicago press edition, 2011.

Durkin, J., Jackson, D., and Usher, K. Touch in times of COVID-19: Touch hunger hurts. *Journal of Clinical Nursing*, 30(1-2):e4–e5, January 2021. ISSN 1365-2702. doi: 10.1111/jocn.15488.

Esling, P. and Devis, N. Creativity in the era of artificial intelligence, August 2020. URL http://arxiv.org/abs/2008.05959. arXiv:2008.05959 [cs].

Fang, T., Qi, Y., and Pan, G. Reconstructing Perceptive Images from Brain Activity by Shape-Semantic GAN. In *Advances in Neural Information Processing Systems*, volume 33, pp. 13038–13048. Curran Associates, Inc., 2020. URL https://proceedings.neurips.cc/paper/2020/hash/9813b270ed0288e7c0388f0fd4ec68f5-Abstract.html.

Fishkin, K. P. A taxonomy for and analysis of tangible interfaces. *Personal and Ubiquitous Computing*, 8(5): 347–358, September 2004. ISSN 1617-4917. doi: 10.1007/s00779-004-0297-4. URL https://doi.org/10.1007/s00779-004-0297-4.

Ford, C. and Bryan-Kinns, N. Speculating on Reflection and People's Music Co-Creation with AI. *In Generative AI and HCI Workshop at CHI 2022*, 2022.

Guilford, J. P. Creativity. *American Psychologist*, 5(9):444–454, 1950. ISSN 1935-990X, 0003-066X. doi: 10.1037/h0063487. URL http://doi.apa.org/getdoi.cfm?doi=10.1037/h0063487.

Hertzmann, A. Aesthetics of Neural Network Art, March 2019. URL http://arxiv.org/abs/1903.05696. arXiv:1903.05696 [cs].

Horikawa, T., Tamaki, M., Miyawaki, Y., and Kamitani, Y. Neural Decoding of Visual Imagery During Sleep. *Science*, 340(6132):639–642, May 2013. doi: 10.1126/science.1234330. URL https://www.science.org/doi/10.1126/science.1234330. Publisher: American Association for the Advancement of Science.

Huang, Q., Jansen, A., Lee, J., Ganti, R., Li, J. Y., and Ellis, D. P. W. MuLan: A Joint Embedding of Music Audio and Natural Language, August 2022. URL http://arxiv.org/abs/2208.12415. arXiv:2208.12415 [cs, eess, stat].

Hui, Y. Imagination and the Infinite: a Critique of Artificial Imagination. *Balkan Journal of Philosophy*, January 2023. URL https://www.academia.edu/101140276/

IMAGINATION_AND_THE_INFINITE_A_CRITIQUE_OF_ARTIFICIAL_IMAGINATION.

Jain, A., Mildenhall, B., Barron, J. T., Abbeel, P., and Poole, B. Zero-Shot Text-Guided Object Generation with Dream Fields, May 2022. URL http://arxiv.org/abs/2112.01455. arXiv:2112.01455 [cs].

Jetchev, N. ClipMatrix: Text-controlled Creation of 3D Textured Meshes, September 2021. URL http://arxiv.org/abs/2109.12922. arXiv:2109.12922 [cs].

Jing, L. and Tian, Y. Self-supervised Visual Feature Learning with Deep Neural Networks: A Survey, February 2019. URL http://arxiv.org/abs/1902.06162. arXiv:1902.06162 [cs].

Jones, L., Nousir, A., Chen, R. X., Liu, A., Donovan, M., Wallace, E., and Nabil, S. Making From Home: Reflections on Crafting Tangible Interfaces for Stay-at-home Living. In *Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction*, TEI '23, pp. 1–16, New York, NY, USA, 2023. Association for Computing Machinery. ISBN 978-1-4503-9977-7. doi: 10.1145/3569009.3572744. URL https://dl.acm.org/doi/10.1145/3569009.3572744.

Kaufman, J. C. and Sternberg, R. J. (eds.). *The Cambridge Handbook of Creativity*. Cambridge University Press, 2 edition, April 2019. ISBN 978-1-316-97983-9 978-1-107-18848-8 978-1-316-63854-5. doi: 10.1017/9781316979839. URL https://www.cambridge.org/core/product/identifier/9781316979839/type/book.

Khanjani, Z., Watson, G., and Janeja, V. P. Audio deepfakes: A survey. *Frontiers in Big Data*, 5, 2023. ISSN 2624-909X. URL https://www.frontiersin.org/articles/10.3389/fdata.2022.1001063.

Kim, B. and Jung, E.-C. Three unique concept explorations in sketching based on conceptual combinations in associative extension and schematic structure. *Thinking Skills and Creativity*, 48:101281, June 2023. ISSN 1871-1871. doi: 10.1016/j.tsc.2023.101281. URL https://www.sciencedirect.com/science/article/pii/S1871187123000512.

Kivrak, P. Art walks in latent spaces - Goethe-Institut, 2020. URL https://www.goethe.de/prj/k40/en/kun/lat.html.

Li, Y. and Hilliges, O. (eds.). *Artificial intelligence for human computer interaction: a modern approach*. Human-computer interaction series. Springer, Cham, 2021. ISBN 978-3-030-82681-9 978-3-030-82680-2.

Licklider, J. C. R. Man-Computer Symbiosis. *IRE Transactions on Human Factors in Electronics*, HFE-1(1):4–11, March 1960. ISSN 2168-2836. doi: 10.1109/THFE2.1960.4503259. Conference Name: IRE Transactions on Human Factors in Electronics.

Lin, S., Sprague, T., and Singh, A. K. Mind Reader: Reconstructing complex images from brain activities, September 2022. URL http://arxiv.org/abs/2210.01769. arXiv:2210.01769 [cs, eess, q-bio].

Liu, V. Beyond Text-to-Image: Multimodal Prompts to Explore Generative AI. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*, CHI EA '23, pp. 1–6, New York, NY, USA, April 2023. Association for Computing Machinery. ISBN 978-1-4503-9422-2. doi: 10.1145/3544549.3577043. URL https://dl.acm.org/doi/10.1145/3544549.3577043.

Liu, V. and Chilton, L. B. Design Guidelines for Prompt Engineering Text-to-Image Generative Models. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, CHI '22, pp. 1–23, New York, NY, USA, 2022. Association for Computing Machinery. ISBN 978-1-4503-9157-3. doi: 10.1145/3491102.3501825. URL https://dl.acm.org/doi/10.1145/3491102.3501825.

Liu, V., Qiao, H., and Chilton, L. Opal: Multimodal Image Generation for News Illustration, August 2022. URL http://arxiv.org/abs/2204.09007. arXiv:2204.09007 [cs].

Liu, Y., Jun, E., Li, Q., and Heer, J. Latent Space Cartography: Visual Analysis of Vector Space Embeddings. *Computer Graphics Forum*, 38(3):67–78, 2019. ISSN 1467-8659. doi: 10.1111/cgf.13672. URL https://onlinelibrary.wiley.com/doi/abs/10.1111/cgf.13672. _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1111/cgf.13672.

Lizé Masclef, N. Strange Loops : Augmenting Feelings. In *Proceedings of the Seventeenth International Conference on Tangible, Embedded, and Embodied Interaction*, pp. 1–3, Warsaw Poland, February 2023. ACM. ISBN 978-1-4503-9977-7. doi: 10.1145/3569009.3576190.

Lizé Masclef, N. and Chuttarsing, A. Latent Organism: Embodied Co-Creation with AI. In *Creativity and Cognition*, pp. 239–242, Virtual Event USA, June 2023a. ACM. ISBN 9798400701801. doi: 10.1145/3591196.3593508. URL https://dl.acm.org/doi/10.1145/3591196.3593508.

Lizé Masclef, N. and Chuttarsing, A. Latent Organism: A tangible interface for 3D co-creation with AI. 2023b.

doi: 10.14236/ewic/EVA2023.30. URL https://scienceopen.com/hosted-document?doi=10.14236/ewic/EVA2023.30.

Lizé Masclef, N. and Reed, K. M. Bio Deepfakes, Mimicry and Memes. In *CHI'23 Workshop on Living Bits and Radical Aminos*, Hamburg, Germany, 2023. Association for Computing Machinery, New York, NY, United States.

Michel, O., Bar-On, R., Liu, R., Benaim, S., and Hanocka, R. Text2Mesh: Text-Driven Neural Stylization for Meshes, December 2021. URL http://arxiv.org/abs/2112.03221. arXiv:2112.03221 [cs].

Mithen, S. J. *The prehistory of the mind: the cognitive origins of art, religion and science*. Thames and Hudson, London New York, 1st paperback ed edition, 1999. ISBN 978-0-500-28100-0.

Moulon, D. Intelligence in art. *Art Press*, January 2021. URL https://www.academia.edu/60516885/Intelligence_in_art.

Ozcelik, F. and VanRullen, R. Brain-Diffuser: Natural scene reconstruction from fMRI signals using generative latent diffusion, March 2023. URL http://arxiv.org/abs/2303.05334. arXiv:2303.05334 [cs, q-bio].

Picard, R. W. *Affective computing*. MIT Press, Cambridge, Mass, 1997. ISBN 978-0-262-16170-1.

Poole, B., Jain, A., Barron, J. T., and Mildenhall, B. DreamFusion: Text-to-3D using 2D Diffusion, September 2022. URL http://arxiv.org/abs/2209.14988. arXiv:2209.14988 [cs, stat].

Radford, A., Kim, J. W., Hallacy, C., Ramesh, A., Goh, G., Agarwal, S., Sastry, G., Askell, A., Mishkin, P., Clark, J., Krueger, G., and Sutskever, I. Learning Transferable Visual Models From Natural Language Supervision, February 2021. URL http://arxiv.org/abs/2103.00020. arXiv:2103.00020 [cs].

Sarkar, A. Enough With "Human-AI Collaboration". In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*, CHI EA '23, pp. 1–8, New York, NY, USA, 2023. Association for Computing Machinery. ISBN 978-1-4503-9422-2. doi: 10.1145/3544549.3582735. URL https://dl.acm.org/doi/10.1145/3544549.3582735.

Senden, M., Emmerling, T. C., van Hoof, R., Frost, M. A., and Goebel, R. Reconstructing imagined letters from early visual cortex reveals tight topographic correspondence between visual mental imagery and perception. *Brain Structure and Function*, 224(3):1167–1183, April 2019. ISSN 1863-2653, 1863-2661. doi: 10.1007/s00429-019-01828-6. URL http://link.springer.com/10.1007/s00429-019-01828-6.

Shen, G., Horikawa, T., Majima, K., and Kamitani, Y. Deep image reconstruction from human brain activity. *PLOS Computational Biology*, 15(1):e1006633, January 2019. ISSN 1553-7358. doi: 10.1371/journal.pcbi.1006633. URL https://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1006633. Publisher: Public Library of Science.

Singh, G., Deng, F., and Ahn, S. Illiterate DALL-E Learns to Compose, March 2022a. URL http://arxiv.org/abs/2110.11405. arXiv:2110.11405 [cs].

Singh, N., Bernal, G., Savchenko, D., and Glassman, E. L. Where to Hide a Stolen Elephant: Leaps in Creative Writing with Multimodal Machine Intelligence. *ACM Transactions on Computer-Human Interaction*, 2022b. ISSN 1073-0516. doi: 10.1145/3511599. URL https://dl.acm.org/doi/10.1145/3511599. Just Accepted.

Takagi, Y. High-resolution image reconstruction with latent diffusion models from human brain activity, March 2023. URL https://github.com/yu-takagi/StableDiffusionReconstruction. original-date: 2023-02-28T08:42:17Z.

Takagi, Y. and Nishimoto, S. High-resolution image reconstruction with latent diffusion models from human brain activity, November 2022. URL https://www.biorxiv.org/content/10.1101/2022.11.18.517004v1. Pages: 2022.11.18.517004 Section: New Results.

Wan, Q. and Lu, Z. Investigating Semantically-enhanced Exploration of GAN Latent Space via a Digital Mood Board. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems*, pp. 1–5, Hamburg Germany, April 2023. ACM. ISBN 978-1-4503-9422-2. doi: 10.1145/3544549.3585740. URL https://dl.acm.org/doi/10.1145/3544549.3585740.

Wang, Y., Shen, S., and Lim, B. Y. RePrompt: Automatic Prompt Editing to Refine AI-Generative Art Towards Precise Expressions. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, pp. 1–29, Hamburg Germany, April 2023. ACM. ISBN 978-1-4503-9421-5. doi: 10.1145/3544548.3581402. URL https://dl.acm.org/doi/10.1145/3544548.3581402.

Wenskovitch, J. Interactive AI: Designing for the "Two Black Boxes" Problem. 2020.

Whorf, B. L. *Science and linguistics*. Technology Review, Cambridge, Mass., 1940. OCLC: 663687742.