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Pushing divergence and promoting convergence in a speculative design process: Considerations on the role of AI as a co-creation partner

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Abstract: Within design research, several studies have looked at Artificial Intelligence as a tool to help ideation processes. However, the potential of using Artificial Intelligence to support a specific characteristic of the design process, namely the interplay between divergent and convergent thinking, remains underexplored. Aiming to address this gap, this paper examines how 136 students interacted with Artificial Intelligence on the occasion of two courses run by the authors in a prominent European design school.

Keywords: speculative design; convergent and divergent thinking; design research; artificial intelligence

1. Introduction

Already in 1961, Raymond Queneau published *Cent Mille Milliards de Poémes* (*One Hundred Thousand Billion Poems*), as a book composed of ten poems whose lines can be recombined to create a hundred thousand billion properly-formed sonnets (Queneau, 1961). Shortly after, Italo Calvino argued that writing is a combinatorial game (Calvino, 1986), which can be characterized by algorithmic generation (Calvino, 1995). These projects can be considered as literary antecedents for a specific stream of artistic experimentation that explored Artificial Intelligence-based art and literary practices (Zhu & Harrell, 2011).

Starting from some landmark papers in the 1950s (Turing, 1950), scholars from different disciplines proposed numerous definitions of Artificial Intelligence (AI) (e.g. for two recent reviews, see Wang, 2019; Wirth, 2018). For the scope of this paper, we will adopt the broad definition proposed by Elaine Rich some 30 years ago: “Artificial Intelligence is the study of how to make computers do things that people are better at” (Rich, 1985, p. 117), which we consider still valid. We are particularly interested in how AI can support creative thinking and

processes - primarily thanks to the particular way in which computational techniques operate (Manovich, 2001).

Within design research, several studies have looked at AI, mainly as a tool to support ideation processes within the fields of engineering and architecture (e.g. Camburn et al., 2020; Serra & Miralles, 2021; Singh & Gu, 2012; Zhang et al., 2021). However, the potential of using AI to support a specific characteristic of the design process, namely the interplay between divergent and convergent thinking, remains underexplored. Yet, the design process has been often characterized as a framework that facilitates phases in which divergent thinking pushes towards multiple options and phases in which convergent thinking elaborates these options and selects the most promising and desirable, thus narrowing down the design process (e.g. Cross, 1985, 2008). The scope of this paper is precisely to investigate whether having an AI as a co-creation partner in a design process can affect divergent and convergent thinking and, if so, how. We do so by examining the way in which 136 students – grouped in 22 teams of 5 students - interacted with an AI on the occasion of two courses run by the authors in a prominent European design school.

The paper is organized as follows: Section 2 reviews the literature, with a particular focus on creative thinking and previous studies that looked at AI as a co-creation partner in design. Section 3 describes the research approach. Section 4 presents the study's findings. Section 5 discusses the findings and Section 6 concludes the paper by underlining some limitations.

2. Theoretical background

2.1 Convergent thinking and divergent thinking

In the past decades, a recurring leitmotif has been the characterization of creative thinking in terms of a combination of convergent and divergent thinking (Cropley, 2006). Divergent thinking has been traditionally linked to concepts such as fluency (i.e., the capacity to generate scores of ideas), flexibility (i.e., the capacity to switch viewpoints and approaches) and originality (i.e. the pursuit of uncommon lines of thought) (Guilford, 1950; Mumford, 2001). Convergent thinking, which was characterized as being based on knowledge of facts, was often presented as a conflicting or competing way of thinking, as "a necessary evil that is greatly exaggerated in education and business" (Cropley, 2006, p. 391; see also e.g. Getzels & Jackson, 1962). Over time, researchers painted a more nuanced view of the interplay of convergent and divergent thinking and understood the critical role played by convergent thinking in anchoring the ideas generated through the divergent thinking process to the specificities of the problem and the context at hand (e.g. Brophy, 1998; Rickards, 1993).

The figure below summarizes typical cognitive processes associated with convergent and divergent thinking as presented by Cropley (2006).

	Typical processes
Convergent thinking	Being logical, Recognizing the familiar, Clustering similar items, Reapplying set techniques, Preserving the already known, Achieving accuracy and correctness, Playing it safe
Divergent thinking	Being unconventional, Seeing the known in a new light, Combining the disparate, Shifting perspective, Transforming the known, Seeing new possibilities, Taking risks

Figure 1. Cognitive processes associated with convergent and divergent thinking (re-elaborated from Cropley, 2006)

Within design research, the distinction between convergent and divergent thinking was introduced decades ago (Cross, 1985) and, since then, the design process has been recurrently characterized as a structured framework through which design methods can support these two different and complementary ways of thinking (Cross, 2008; Drew, 2019).

2.2 AI as a co-creation partner in design

The capacity of AI to process data to serve expressive purposes has been examined by scholars studying digital and interactive media, software, computer games and, broadly, digital computer simulation (Harrell, 2010; Mateas, 2002; Wardrip-Fruin, 2009). While earlier studies broadly looked into the impact that algorithmic operations have on our cognitive functions and reasoning (Suchman, 1987; Weizenbaum, 1977; Winograd & Flores, 1986), a more distinct research stream has more recently focused on creative processes, noting how "computational processes are an increasingly significant means of expression" (Wardrip-Fruin, 2009, p. 3) and that "algorithmic processing and data structuring [can be effectively used] as expressive bases for expressing commentary about, and making impactful change upon, the world of human experience" (Harrell, 2010). Within this stream, early research had already highlighted the potential of computational processes to support creative practices such as remix, mashup, remediation and remake (Manovich, 2001), also pointing towards the connection with some of the practices of the modernist avant-garde art (Manovich, 1996). AI is seen as a potential partner in collaborative processes, even though some studies still show that the propensity of humans to cooperate with AI is lower than that toward humans (Ishowo-Oloko et al., 2019; Rovatsos, 2019).

With specific reference to design, several researchers studied how AI could be used to support the creative process and particularly the ideation stages. Camburn and colleagues showed how computer-aided mind map generation in engineering design can effectively

support early-stage ideation by fostering processes of design concepts generation and of clustering of these concepts (Camburn et al., 2020). Singh and Gu reviewed how generative design systems can assist design exploration in architecture (Singh & Gu, 2012). The authors argued that current generative systems tend to be conceived as to support a single specific technique in design generation (e.g. shape grammars, L-systems, cellular automata, genetic algorithms and swarm intelligence) and that, conversely, there is the need for a broader framework that encompasses multiple techniques at once. The authors also briefly suggest that these generative systems can be beneficial in encouraging divergent thinking. In a recent study, Serra and Miralles worked on a constructive design tool, which is based on a shape grammar and that can be used by humans and AI agents during a design process (Serra & Miralles, 2021). Comparing the proposals of the artificial agent with the ones produced by humans in terms of novelty and performance, the authors found out that the AI could generate results similar to those produced by humans and, in some cases, even solutions not considered by humans. In another recent paper, Zhang and colleagues presented the results of a human subject study that assessed the impact of a design learning AI on distributed design teams. They noted how the AI helped low performing-design teams (at least in the initial sessions of the process), but it reduced the performance of high-performing teams. The reasons behind the reduced performance can be explained through "the cognitive overload, the flawed inference from AI suggestions, and a lack of motivation among participants to find better designs in the study" (Zhang et al., 2021). As such, the authors warned against the simplistic idea that AI can be a silver bullet in supporting design processes.

These studies cast some light on the potential of using AI to support design processes. However, as suggested by Zhang and colleagues, even though current research involving AI in design processes is promising, generally, "human designers treat AI as a design tool rather than their teammate" (Zhang et al., 2021). Our paper intends to contribute to the existing design literature by proposing three elements of originality: (1) we specifically look into how AI can be used - as a co-creation partner - in specific relation to creative thinking and, namely, the two constructs of convergent and divergent thinking; (2) as suggested by previous studies in the fields of digital and interactive media, software, computer games and, broadly, digital computer simulation, we explore AI-supported creative practices of remix and mashup; (3) we focus our analysis on the context of speculative design, while the above-mentioned studies refer to engineering and architecture. In our study, we invited the participants to interact with an AI during a process aimed at designing experiential futures, i.e. "the design of situations and stuff from the future to catalyse insight and change" (Candy & Dunagan, 2017, p. 137). In other words, participants were asked to develop possible future worlds through fictional prototypes of future artifacts, which emerged from a "conflation of design, science fact and science fiction" (Bleecker, 2009, p. 6).

The research question that we explore is: *Can engaging with an AI as a co-creation partner affect processes of divergent and convergent thinking in a design process?*

3. Methods

The empirical material analyzed in this paper emerged from an experimental setting (Binder & Redström, 2006; Brandt & Binder, 2007; Eriksen & Bang, 2013), whose backbone was a 6-month project in which two of the authors run two interaction design courses (at a bachelor's level) for a design school in Europe. During the courses, 136 students worked in teams (maximum 5 people) to develop ideas for physical products or interactive services that would explore forms of human-computer interaction mediated by AI. The students were invited to follow a speculative design approach and produce provocative prototypes (Dunne and Raby, 2013), experiential and immersive future simulations (Candy & Dunagan, 2017), and design fiction representations (Sterling, 2009). Throughout the course, each team also had to interact with an AI as a co-creation partner. This was done through 2 or 3 sessions in which each team sat in front of a laptop and interacted with the AI, typing questions and sharing short summaries of their creative ideas (in written form). The AI would reply to these questions and inputs, providing short written texts. Typically, the students would interact with the AI at three stages: (a) at an early ideation stage (e.g., using the answers provided by the AI to explore possible creative directions), (b) at a subsequent stage in which the students already chose a specific area they wanted to work with (and looked for the support of the AI in refining their creative trajectory) and, finally, (c) at a later stage when the students already settled on a specific idea and used the AI to produce related creative elements.

After the course, all the students participated in a survey that contained questions aimed at understanding whether and how the interaction with the AI affected their design processes. In addition, during the final oral exam in which the teams presented their work, one of the authors had the chance to talk to each team and gather additional feedback asking specific questions and taking notes. While the response rate for the survey was 50%, all the teams went through the final oral exam and, therefore, the authors managed to collect feedback from all the teams.

In summary, the specific positioning of the authors allowed to gather data through three main methods: (1) participant observation (Czarniawska, 2012), carried out by taking notes and observing how the teams interacted with the AI during the co-creation sessions, (2) the final survey and (3) additional questions in the occasion of the final exam. We progressed through iterative processes of data reduction, analysis, formulation of working hypotheses, and verification (Corbin & Strauss, 2008; Miles et al., 2014). The authors of the paper were at first working independently on the data and then shared their analyses in order to seek the highest degree of reliability (Gilmore & Coviello, 1999). In particular, both authors initially engaged in independent qualitative coding and later integrated their work to check the reliability of their coding processes.

3.1 Technical architecture

The technical architecture was developed in Javascript and Python and emerged from an assemblage of two different environments: (1) deep learning algorithms (LSTM as a character-

based recurrent neural network based on TensorFlow char-rnn), used inside a Javascript library for processing (ml5.js); these algorithms were chosen to give the students the possibility to brainstorm with the AI and customise the user interface; (2) a Generative Pre-trained Transformer (the GPT-2 model, built on Open AI's GPT-2 Language Model, inside the Google CoLab environment) (Radford et al., 2019). The GPT-2 algorithm was trained on the task of language modeling - which tests a program's ability to predict the next word in a given sentence - by ingesting a specific corpus, i.e. a collection of machine-readable texts that were produced in a natural communicative setting and that fed the computational processes of the AI and its expressive capacity. In the specific case of the AI used in our experiment, the corpus was composed of a variety of texts, e.g. coming from books, newspaper articles, spoken speech and blog entries. This corpus was partially preloaded by us. Initially, all the students worked with the same language models; afterward, each student team could add further texts to the corpus. Among the texts that we preloaded in the system, there were experimental literary works such as the already cited Queneau's *One Hundred Thousand Billion Poems*, Stéphane Mallarmé's *A Painter's Poet* (Roos et al., 1999) and George Perec's *Species of Spaces* (Perec, 1964/1997). We chose these texts especially for their approach towards combinatory writing, i.e. "the seeking of … structures and patterns which may be used by writers in any way they enjoy" as described by some of the authors mentioned above with regard to their workshop of potential literature *Oulipo* (Paine, 2009). Our system was fed with some material in English and Italian and, therefore, could function in both languages.

4. Findings

The students carried out their speculative design projects throughout the first 6 months of 2021. The students were divided into 22 teams and, on average, they interacted with the AI 2 or 3 times - mostly during early ideation phases but also at later stages, when the students converged towards a specific idea and wanted to share this idea with the AI to get feedback. The quality of the answers provided by the AI depended on the corpus – which, as detailed above, was a mash-up of different texts, some preloaded by the authors and some loaded by the students in relation to their specific domain of interest (e.g., some students fed the AI with some texts related to astrology, some others with slogans from political rallies). The result was a creative remix, whose outputs we could not precisely predetermine. As such, at times, the answers generated by the AI were perceived as quite unsettling and provocatory.

The survey showed that the vast majority of respondents (87%) found the interaction with the AI to be beneficial for their ideation process. This data was supported by the additional answers gathered during the final exam. Mostly, the students noted how the AI had supported them in two phases of the design process: (1) initial brainstorming sessions, in which the teams did not have a specific direction to follow and (2) later ideation phases, in which the students had some a preliminary direction to follow but did not finalize their idea yet.

The case of project *Alpha* is an example of how students interacted with the AI at a preliminary stage of their ideation process. The students were exploring different directions and

could not find an agreement on how to proceed. They started asking random questions to the AI and the AI was providing answers through sequences of small texts, which appeared as loosely connected (or connected by an underlying logic that the students distinctively perceived as non-human). Mostly, these sequences of answers appeared to the students as provocatory, surprising and unsettling. Figure 2 shows an example of a question asked to the students to the AI and the answers provided by the AI. The students were just asking random questions to the AI and, among them, they also asked: "What is your relationship with the sky/heaven? [in Italian, the word *cielo* has a double meaning]. The AI answered: "I don't know... it is something that does not belong to the body... yet, I feel that there is something through which I am connected to the sky/heaven".

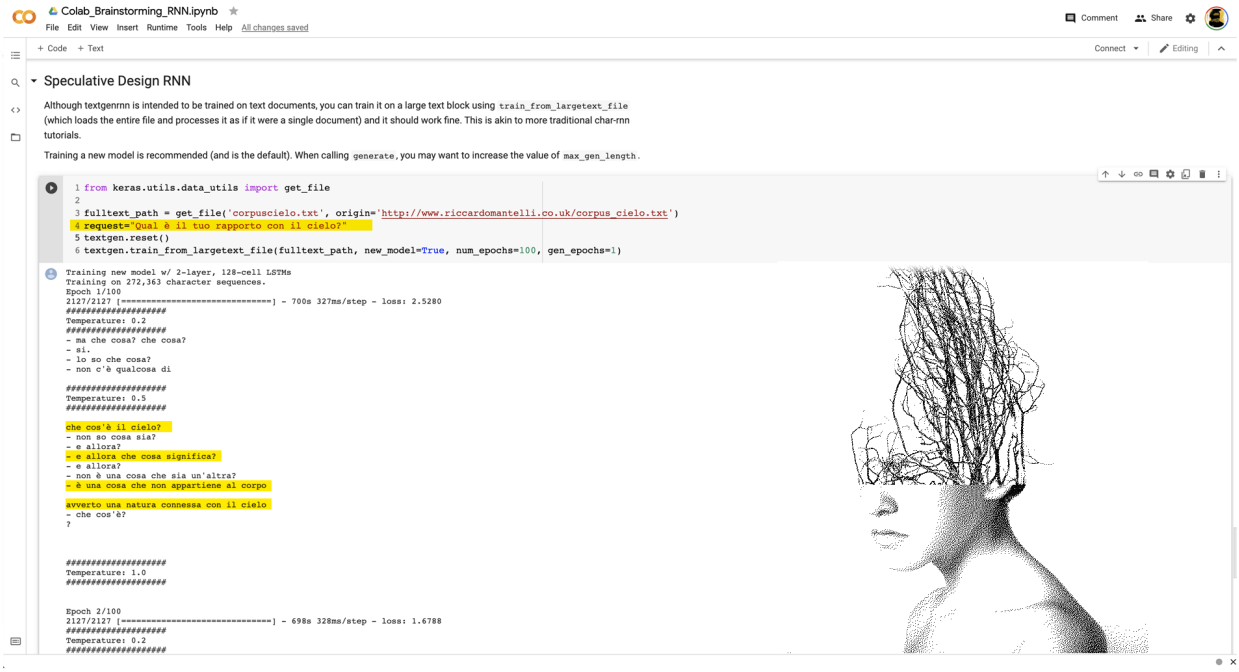

Figure 2. Screenshot presenting an extract of a conversation between students and AI (project Alpha)

This answer intrigued the students and made them interested in exploring whether there could be a world in which the movements and relative positions of celestial objects would affect the functioning of algorithms. As such, they ended up prototyping an interactive physical object (in the form of a crystal ball), which provides divinatory messages about the way in which humans and AIs are going to interact on specific days of the year according to a sort of astrology for AI. Project *Alpha* is an example of a case in which, as also noted by the students in the final survey, the interaction with the AI fueled divergent thinking: "Using the algorithm proposed by the teachers expanded our brainstorming. It has inspired us and has provided new directions in the design phase", "It was great to play and try to use the ideas generated. [We got] many ideas that we did not expect", "Our brainstorming has expanded a lot".

An example of how AI helped students in a slightly later ideation phase was the project *Gamma*. Here, the students already decided that they wanted to explore new forms of human-computer interaction mediated by AI, but they did not know what specific form this interaction should take. Within the traditional design framework of the double diamond (Drew, 2019), the students were in the second diamond: they had already converged towards a specific problem definition and now they needed to go through another cycle of divergent thinking to explore ideas and solutions. When dialoguing with the AI (see Figure 3), the students asked "How to improve the interaction among us?" and they got an answer from the AI that pointed toward exploring 'sound' or 'light' as possible forms of interaction:

> "I listen i listen i listen like in a forest
>
> the sound and light envelop you
>
> the sun follows".

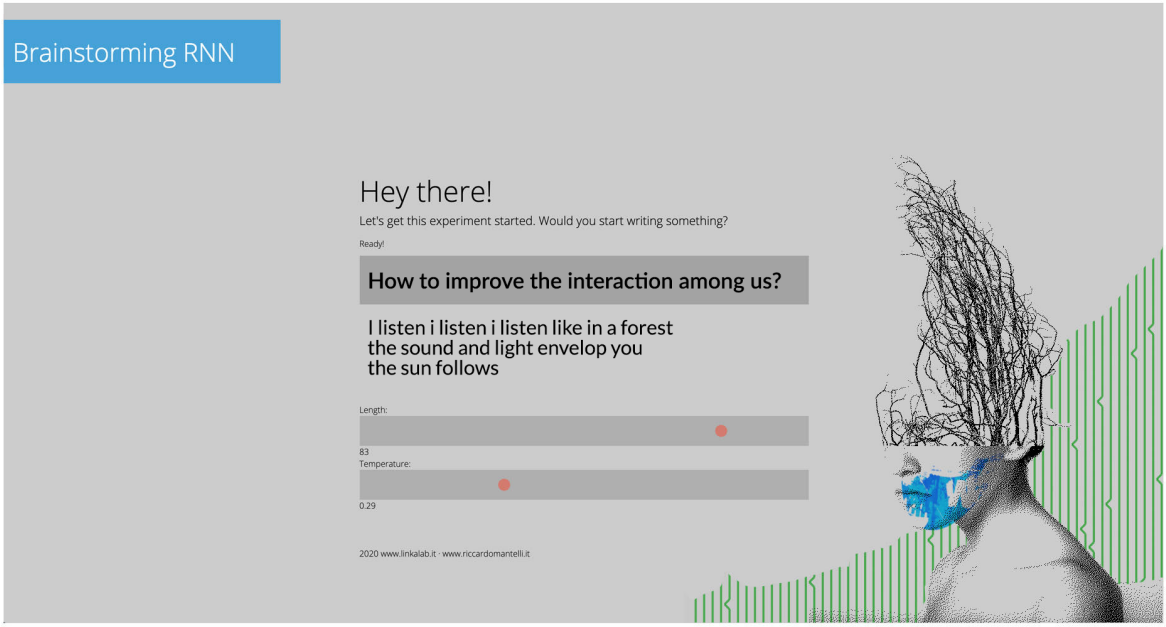

Figure 3. Another screenshot showing an extract from another conversation between students and AI (project Gamma)

This answer supported some divergent thinking (suggesting more than one option: 'sound' and 'light'), but - since only two options were suggested - this helped the team converge towards a narrow set of possibilities. After some deliberation, the students ended up proposing an interactive physical object with a microphone and speakers, which listens to conversations happening among people (e.g. at a party, at a dinner, at a workplace), analyzes these conversations trying to figure out the topics and the mood of the participants and then produces suitable computer-generated soundscapes that accompany these conversations. In

the final survey, students using AI in a later ideation phase (like in the case of project *Gamma*) pointed to the role of the AI in re-interpreting things from a different perspective: "We have inserted sentences on a topic into the algorithm. The algorithm has put them back together according to its way of seeing things." The students saw how the interaction with the AI could be valuable not just as a way to propose (almost) random directions to follow (like in earlier ideation processes) but also as a co-creation partner that would select the material and interpret it according to its own logic.

A third example shows another way in which this 'interpretive' and creative side of the AI was recognized and used by the students. In the *Beta* project, the idea developed by the students was that of a future in which increasingly autonomous AIs have come to recognize the similarity between their work - carried out continuously, night and day, without a break - and the repetitive and alienating work of the factory workers on an assembly line. These AIs realized their vital contribution to the functioning of our society and, as such, demanded to establish new rights and regulations to protect them. Once this idea crystallized in their mind, the students decided to use the AI as a co-creation partner to actually shape some of the material to present this idea. Fed by the students with texts and slogans from political rallies that factory workers organized in the 20th century, the AI created a set of slogans to be used during a political rally in which AIs come together and shout for their rights. Figure 4 presents a selection of these slogans.

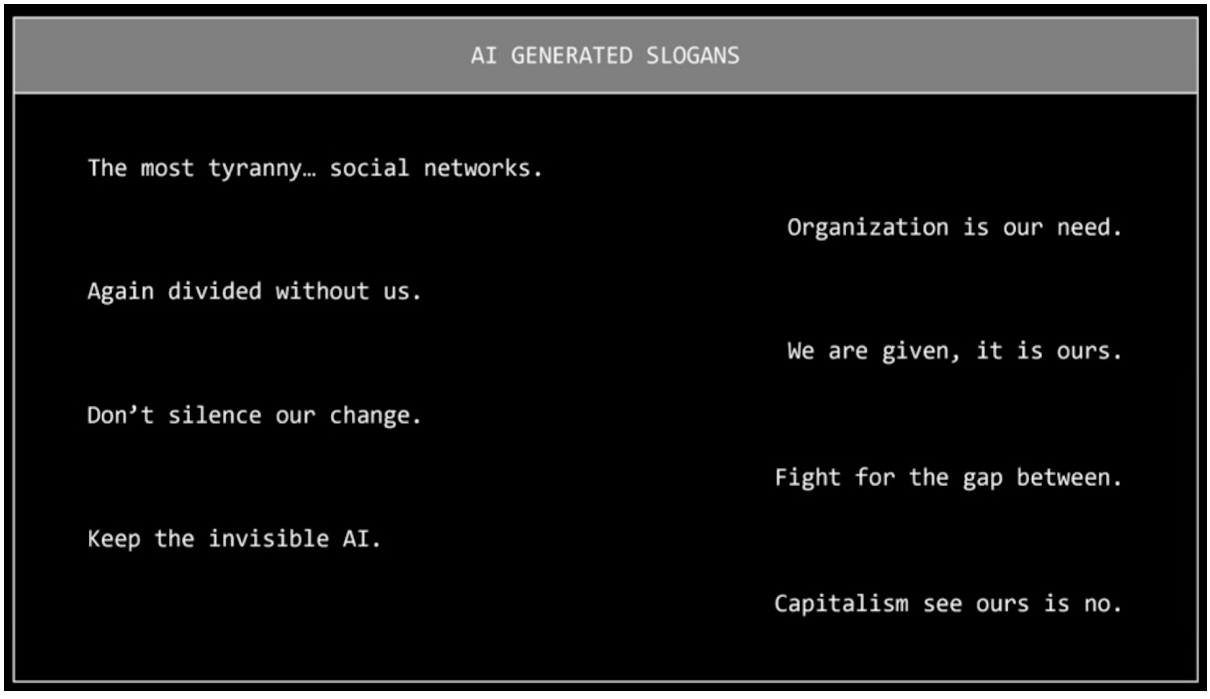

Figure 4. AI-generated slogans from the Beta project

Students noted how through these interactions with the AI happening at later stages of the ideation process, they became more aware of the potential of AI as a proper co-creation partner, able to support the team through refined creative work.

It is important to note that even though the vast majority of the teams found that "it was stimulating to understand the dynamics related to AI and creativity", the majority of students (some 60%) also pointed towards the challenges of working with an AI as a co-creation partner: "It would take much longer to understand how to use properly these artificial intelligence programs", "We would need a simpler way to work with algorithms". The students did not have a thorough preparation in computer science and would have liked to have more time to understand some basic aspects of the inner functioning of AI.

5. Discussion and contribution

This study was geared towards the following research question: *Can engaging with an AI as a co-creation partner affect processes of divergent and convergent thinking in a design process?* Our empirical material showed how the interaction with AI could support these processes at various stages.

At very early ideation phases (e.g. like in the case of the project *Alpha*), the AI acted more as a way to open up possibilities and potential directions to follow. In this phase, the corpus of the AI was only fed with the material that was preloaded by us and, as such, the AI expressed itself by juxtaposing and remixing elements of the preloaded corpus according to the way in which it interpreted the questions of the students. The result was often a series of sentences that looked connected by a logic that distinctively seemed (to the students) as non-human. At times, the sentences provided by the AI were connected by an algorithmic logic that students did not fully comprehend. Similarly to the combinatory poetry explored by Raymond Queneau, the AI was producing sentences assembled in ways that might appear random. These patchworks of short sentences were considered by the students quite inspirational, in a sort of Dadaist way. They suggested multiple interpretive directions and divergent thinking.

At a slightly later stage, the students had already converged towards a single problem definition and they were able to ask more precise questions to the AI (e.g. like in the case of the project *Gamma*). Here, the AI was fed by additional texts proposed by the students and, as a result, the answers provided by the AI worked to suggest a narrower set of possibilities than in the previous phase. As such, the AI was deemed as supportive in not only proposing some possible directions for the ideation (divergent thinking) but also in helping the students converge towards a more limited set of ideas to explore at a more granular level.

Finally, at later stages, when the students already found an idea to work on, the AI helped to shape the idea by producing creative elements, like the slogans elaborated for the project *Beta*. In this phase, the students had the possibility to feed the corpus with additional texts that were specifically focused on the topics that the students wanted to work with. As a consequence, the answers produced by the AI were much more refined and the students could use them as creative bits to present their idea in their final pitch. As such, they felt that the AI could be really characterized as a co-creation partner, rather than just a machine producing random and disconnected answers.

Anchoring these reflections to the literature on divergent and convergent thinking (Cropley, 2006), we argue that AI can support the students across multiple processes. In the divergent thinking phase, the AI would help the students see things in a different way, shift perspectives and combine the disparate. These processes were also facilitated by the particular way in which the AI was built and fed - inspired by the early artistic experiences that explored the role of AI in supporting the creative practices of remix and mashup (Manovich, 2001). Conversely, in the convergent thinking phase, the AI would help the students choose a specific path, play down their differences and come together. In our experiment, at times, within a team, there were few individuals sticking to their own idea and unwilling to abandon it to settle on an idea proposed by another team member. This would create a situation of tension. Following the creative suggestions offered by the AI (rather than the suggestions offered by one of the members of the team) was seen by these teams as a way to break the impasse. In addition, the directions proposed by the AI were evocative and ambiguous rather than clearly defined. This ambiguity gave each team member the possibility to interpret and slightly shape things from their own perspective and feel that they were giving their creative touch to the final idea.

This research contributes to the existing literature that examines the use of AI in the design process (Camburn et al., 2020; Serra & Miralles, 2021; Singh & Gu, 2012), mainly by exploring an expanded role of the AI (Zhang et al., 2021), at a point that the AI is not perceived just as a creative tool but rather as a proper co-creation partner, able to facilitate convergent and divergent thinking. As such, our study also integrates previous work that pointed to collaborative dynamics between humans and AI (Rovatsos, 2019).

We are, of course, aware that some of the dynamics that worked in our case - i.e. in a speculative design process - might not work in other design processes (such as engineering design), which by their nature tend to be less visionary and provocatory than speculative design. The processes of remix and mashup adopted in our experiment and the almost Dadaist way of expressing of our AI might need to be tweaked in order to function in other design fields.

6. Conclusions and limitations

As noted by the design researcher James Auger:

> "Speculative design proposals are essentially tools for questioning. Their aim is therefore not to propose implementable product solutions, nor to offer answers to the questions they pose; they are intended to act like a mirror reflecting the role a specific technology plays or may play in each of our lives, instigating contemplation and discussion."

Our study showed how, indeed, AI could support students to develop questions and to fuel contemplation and discussion. However, in spite of the promising outputs of our study, we consider our research as preliminary and exploratory. We believe that much more can be done to further this study. We recognize that our research is only grounded in the analysis of

a limited number of students and that what worked in a European design school might not work in other contexts. In addition, much more can also be done to analyze the conversations between the AI and the students. In one of his landmark books, Schön brought forward the idea that design is a process where doing and thinking are complementary (reflection-in-action) and analyzes an event in an architectural studio, in particular, a design review where Quist, the studio master, meets Petra, one of his students (Schön, 1987). This fascinating passage very granularly examines how the two interact. In a future paper, it would be great to adopt such a fine-grained perspective to cast a closer look at how the moves of the students and the AI unfold. Such a closer level of zoom would allow adopting research methodologies that could, for example, track the students' perception in relation to each AI suggestion, thus opening the possibility for more accurate measurements. In addition, this examination would also allow considering important aspects that currently remain underexplored, such as: Would the results of the study be different if the AI would just pick random phrases from a large text corpus rather than be trained with a specific corpus? Furthermore, in future research developments, it would be interesting to make students interact, in the fashion of the Turing Test, both with an explicit AI and with a "fake AI" (a remote human user interacting) and with an AI that hides itself looking like a "fake AI ", evaluating the potentially different ways in which the collaboration will unfold in the various cases (Ishowo-Oloko et al., 2019).

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7. References

Binder, T., & Redström, J. (2006). Exemplary Design Research. *Proceedings of DRS Conference*. DRS Conference, Lisbon.

Bleecker, J. (2009). Design Fiction: A Short Essay on Design, Science, Fact and Fiction. *Near Future Labatory*, 49.

Brandt, E., & Binder, T. (2007). Experimental design research: Genealogy, intervention, argument. *Proceedings of International Association of Societies of Design Research, Hong Kong*. http://www.sd.polyu.edu.hk/iasdr/proceeding/papers/Experimental%20design%20research_%20genealogy%20-%20intervention%20-%20argument.pdf

Brophy, D. R. (1998). Understanding, Measuring, and Enhancing Individual Creative Problem-Solving Efforts. *Creativity Research Journal*, *11*(2), 123–150. https://doi.org/10.1207/s15326934crj1102_4

Calvino, I. (1986). Cybernetics and Ghosts. In *The Uses of Literature*. Harcourt Brace & Company.

Calvino, I. (1995). How I wrote one of my books. In R. Queneau (Ed.), *Oulipo Laboratory: Texts from the Bibliotheque Oulipienne*. Atlas.

Camburn, B., Arlitt, R., Anderson, D., Sanaei, R., Raviselam, S., Jensen, D., & Wood, K. L. (2020). Computer-aided mind map generation via crowdsourcing and machine learning. *Research in Engineering Design*, *31*(4), 383–409. https://doi.org/10.1007/s00163-020-00341-w

Candy, S., & Dunagan, J. (2017). Designing an experiential scenario: The People Who Vanished. *Futures*, *86*, 136–153. https://doi.org/10.1016/j.futures.2016.05.006

Corbin, J. M., & Strauss, A. (2008). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory* (Third Edition edition). SAGE Publications, Inc.

Cropley, A. (2006). In Praise of Convergent Thinking. *Creativity Research Journal*, *18*(3), 391–404. https://doi.org/10.1207/s15326934crj1803_13

Cross, N. (1985). Styles of learning, designing and computing. *Design Studies*, *6*(3), 6.

Cross, N. (2008). *Engineering Design Methods: Strategies for Product Design* (4th ed.). Wiley.

Czarniawska, B. (2012). Organization Theory Meets Anthropology: A Story of an Encounter. *Journal of Business Anthropology*, *1*(1), 118–140.

Drew, C. (2019, September 3). *The Double Diamond: 15 years on*. Design Council. https://www.designcouncil.org.uk/news-opinion/double-diamond-15-years

Eriksen, M. A., & Bang, A. L. (2013). Experiments all the way—Diagrams of dialectics between a design research program and experiments. *Proceedings of Nordes*, 238–247.

Getzels, J. W., & Jackson, P. W. (1962). *Creativity and Intelligence*. John Wiley & Sons Inc.

Gilmore, A., & Coviello, N. (1999). Methodologies For Research at the Marketing/Entrepreneurship Interface. *Journal of Research in Marketing and Entrepreneurship*, *1*(1), 41–53. https://doi.org/10.1108/14715209980001555

Guilford, J. P. (1950). Creativity. *American Psychologist*, *5*(9), 444–454. https://doi.org/10.1037/h0063487

Harrell, D. F. (2010). Toward a Theory of Critical Computing; The Case of Social Identity Representation in Digital Media Applications. *CTheory*, 5/13/2010-5/13/2010.

Ishowo-Oloko, F., Bonnefon, J.-F., Soroye, Z., Crandall, J., Rahwan, I., & Rahwan, T. (2019). Behavioural evidence for a transparency–efficiency tradeoff in human–machine cooperation. *Nature Machine Intelligence*, *1*(11), 517–521. https://doi.org/10.1038/s42256-019-0113-5

Manovich, L. (1996). The death of computer art. *Rhizome*. http://rhizome.org/

Manovich, L. (2001). *The Language of New Media*. MIT Press.

Mateas, M. (2002). *Interactive drama, art and artificial intelligence* [Phd]. Carnegie Mellon University.

Miles, M. B., Huberman, A. M., & Saldana, J. M. (2014). *Qualitative Data Analysis: A Methods Sourcebook* (Third edition). SAGE Publications, Inc.

Mumford, M. D. (2001). Something Old, Something New: Revisiting Guilford's Conception of Creative Problem Solving. *Creativity Research Journal*, *13*(3–4), 267–276. https://doi.org/10.1207/S15326934CRJ1334_04

Perec, G. (1997). *Species of Spaces* (J. Sturrock, Trans.). Penguin. (Original work published 1964)

Queneau, R. (1961). *Cent Mille Milliards de Poèmes*. Gallimard.

Rich, E. (1985). Artificial Intelligence and the Humanities. *Computers and the Humanities*, *19*(2), 117–122.

Rickards, T. J. (1993). Creativity from a business school perspective: Past, present and future. In S. G. Isaksen, M. C. Murdock, R. L. Firestien, & D. J. Treffinger (Eds.), *Nurturing and Developing Creativity: The Emergence of a Discipline* (pp. 155–176). Praeger.

Roos, J. M., Plottel, J. P., Caws, M. A., Bonnetoy, Y., & Bonnetoy, C. (1999). *A Painter's Poet: Stephane Mallarme & His Impressionist Circle*. Hunter College Art Galleries.

Rovatsos, M. (2019). We may not cooperate with friendly machines. *Nature Machine Intelligence*, *1*(11), 497–498. https://doi.org/10.1038/s42256-019-0117-1

Schön, D. A. (1987). *Educating the reflective practitioner*. Jossey-Bass.

Serra, G., & Miralles, D. (2021). Human-level design proposals by an artificial agent in multiple scenarios. *Design Studies*, *76*, 101029. https://doi.org/10.1016/j.destud.2021.101029

Singh, V., & Gu, N. (2012). Towards an integrated generative design framework. *Design Studies*, *33*(2), 185–207. https://doi.org/10.1016/j.destud.2011.06.001

Sterling, B. (2009). Cover Story: Design Fiction. *ACM Interactions*, *16*(3), 20–24.

Suchman, L. A. (1987). *Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge University Press.

Turing, A. (1950). Computing machinery and intelligence. *Mind*, *49*, 433–460.

Wang, P. (2019). On Defining Artificial Intelligence. *Journal of Artificial General Intelligence*, *10*(2), 1–37. https://doi.org/10.2478/jagi-2019-0002

Wardrip-Fruin, N. (2009). *Expressive Processing: Digital Fictions, Computer Games, and Software Studies*. MIT Press.

Weizenbaum, J. (1977). *Computer Power and Human Reason: From Judgement to Calculation* (New edizione). W H Freeman & Co.

Winograd, T., & Flores, F. (1986). *Understanding Computers and Cognition: A New Foundation for Design*. Ablex Publishing.

Wirth, N. (2018). Hello marketing, what can artificial intelligence help you with? *International Journal of Market Research*, *60*(5), 435–438. https://doi.org/10.1177/1470785318776841

Zhang, G., Raina, A., Cagan, J., & McComb, C. (2021). A cautionary tale about the impact of AI on human design teams. *Design Studies*, *72*, 100990. https://doi.org/10.1016/j.destud.2021.100990

Zhu, J., & Harrell, D. F. (2011). A Journey along the Borderland: A Critical Approach to Artificial Intelligence-Based Art and Literary Practices. In *Arts: A Science Matter: Vol. Volume 2* (pp. 222–246). WORLD SCIENTIFIC. https://doi.org/10.1142/9789814324946_0011

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