# AI as an Active Writer: Interaction strategies with generated text in human-AI collaborative fiction writing

Daijin Yang[1], Yanpeng Zhou[2], Zhiyuan Zhang[3], Toby Jia-Jun Li[4] and Ray LC[3]

[1]Northeastern University, 360 Huntington Ave, Boston, MA 02115, USA
[2]Nanyang Technological University, 50 Nanyang Ave, 639798, Singapore
[3]City University of Hong Kong,Tat Chee Avenue, Kowloon Tong, 518057, Hong Kong
[4]University of Notre Dame, Notre Dame, IN 46556, USA

**Abstract**

Machine Learning (ML) has become an important part of the creative process for human fiction writers, allowing them to utilize various sources of information and be inspired by strategies and data previously seldom explored. To investigate how human writers collaborate with ML systems in fiction writing, we prototyped a web-based human-AI collaborative writing tool that allows writers to shorten, edit, summarize, and regenerate text produced by AI. To investigate the dynamics of human-AI interaction in fiction co-writing, we used a "finish each other's story" approach where humans and machines took turns writing collaborative fiction. In results from a preliminary study with 9 users, we found that users took inspiration from unexpected text generated by the machine, that users expected reduced fluency and coherence in the machine text when allowed to edit the output, and that they perceived a mental model of the AI as an active writer in the collaborative process rather than simply as a passive AI writing assistant. This study provides design implications on supporting co-creative writing of humans and machines.

**Keywords**

Applications of intelligent user interfaces, Collaborative interfaces, User Modelling for Intelligent Interfaces, Evaluations of intelligent user interfaces - Reproducibility

## 1. Introduction

The rapid development of machine learning has made it possible for artificial intelligence (AI) to collaborate with humans to generate creative content [1, 2, 3, 4, 5, 6]. Human-AI collaborative creative systems based on machine learning have been gradually entering people's creative artistic life such as music composition [6, 7, 8], creative illustration [1, 9], and co-writing [10, 11]. These human-AI collaborative creation systems can assist experienced creators by inspiring them with new ideas and providing suggestions [12, 13]. They can also bring a novel creative experience to users who have no or little creative experience, such as completing the drawing that the user has started or automatically filling in the user's unfinished sentence [1, 10]. In this article, we focus on the needs of users when they collaborate with AI for creative writing.

Recent work is focused on improving the algorithmic performance of natural language generation models, such as improving the logic of generated text [14, 15] or making the generated text closer to the natural language [16, 17]. However, little work focuses on exploring how users perceive the AI used for text generation and how users interact with AI in the creative writing process[18, 19, 20]. Most designs consider collaborative creative writing systems with AI as the user's assistant, such as supplementing the user's unfinished sentences or providing users with suggestions for writing [10, 11, 13]. We seek to explore how an AI system may play a more active role in co-creative writing. Specifically, we explore what interactive capabilities users actually need when co-creative writing with AI, and how these capabilities affect the writing co-creation experience.

To ground our study, we prototyped a collaborative writing system with a web interface for human-AI co-writing. In this system, users and the machine take turns writing paragraphs for each other to continue with. The system has two different modes, the "Edit Mode" and the "No Edit Mode". In our preliminary study with 9 users, each user was first asked to write the beginning of a sci-fi story about human beings finding new homes. A GPT-2-based language model fine-tuned to a sci-fi theme generates follow-up paragraphs of the story based on what users have written. Before continuing writing, users could choose to regenerate or select from multiple versions of machine-generated texts. The machine would consider changes made by users into account for its next generation. In each study sessions, the user and the AI tool finished a 5 paragraph sci-fi story together, with 2 paragraphs generated by the AI, and 3 paragraphs written by the user.

*Joint Proceedings of the ACM IUI Workshops 2022, March 2022, Helsinki, Finland*
yang.dai@northeastern.edu (D. Yang); zydstd@gmail.com (Y. Zhou); zzhang452-c@my.cityu.edu.hk (Z. Zhang); toby.j.li@nd.edu (T. J. Li); LC@raylc.org (R. LC)
© 2022 Copyright for this paper by its authors. Use permitted under Creative Commons License Attribution 4.0 International (CC BY 4.0).
CEUR Workshop Proceedings (CEUR-WS.org)

CEUR-WS.org/Vol-3124/paper6.pdf

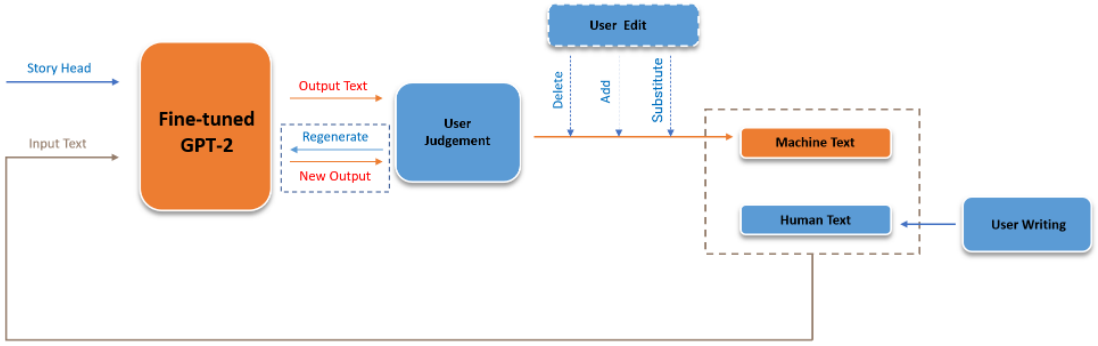


**Figure 1:** The architecture of the prototype human-AI co-writing tool used in this study. First, the story head is written by humans and entered into the fine-tuned GPT-2. The user then judges the text generated by the machine and decides whether to regenerate it. After that, the text generated by the machine is modified by the user as the final machine text. The user follows the story development of machine text to write. Finally, both machine text and human text are used as input for the next machine generation.

By observing 9 users' writing process in two modes, interviewing about their experiences in the co-writing process, and analyzing their written stories, we concluded our main findings as follows:

1) We find the patterns of texts in Human-AI collaboratively written stories: The AI-enabled tool served as a good unexpected twist provider but not a fully competent writer.
2) We discover users with different writing intention and in different interactive modes (allowing editing versus not allowing editing) had different mental expectation on text coherence and fluency.
3) We describe users perceptions of machine's role in the co-writing process and discuss future possibility of writing machine.

Taken together, these findings guide the design of future Human-AI co-writing interfaces.

## 2. Related Work

The recent development of AI enabled extensive applications that explored the creation of cooperation between humans and AI, including drawing creation [1, 9, 2], creative writing [10, 11, 3], dance [21] and other fields [22, 23]. For example, Clark et al. conducted a study that explore the use of AI to complete sentences and provide suggestions [13] and Louie et al. built an AI-enabled tool for creating music [6]. In this line of works, the AI acts as the user's collaborator. It can adjust its output according to the goals and actions proposed by the user and then makes corresponding recommendations. In these systems, AI collects the user's input information as to its output condition or predicts the user's true intention based on the user's feedback.The output of our human-machine collaborative innovative writing system is influenced by users' input, which is consistent with previous works. However, our system comes with its own consideration of the plot, while following the user's writing wishes.

Compared with the difficulty of human innovation in story writing, machines cannot fully understand the intentions of human writing, so they are more likely to create unexpected plots and drive the development of the story[24]. Since the self-attention mechanism is mainly used in the current machine language model, the word vector sometimes notices itself thus falls into the looping state of the text [10, 13, 24], especially in the process of generating long text. In addition, the training dataset of the machine is quite larger than the related knowledge in the human brain, so it has the potential to generate interesting story text[25, 26, 27, 24]. Human's logic is stronger than machine's, which is necessary for coherence in creative writing[24].Especially, Humans have a much better common sense world understanding than language models[20]. Hence, combining text generation language models and human writing for innovative writing, including text interactive games, writing assistants and so on, might be a potential way of human-computer interaction. In a text interactive game[28, 29, 30, 31], the user controls the character through natural language, and the AI agent recognizes the user's input, intelligently manipulates the character's actions in a text-described environment, and feeds the results back to the user. AI writing assistant is also an important research field of

human-AI creative writing. The AI writing assistant can correct users' spelling and grammatical errors[10], complete users' unfinished sentences or supplement full-text paragraphs[32], and provide inspiration and suggestions for users' creative writing[13].

# 3. The Collaborative Writing Tool

For our study, we prototyped a web-based collaborative writing tool where the user can co-write a short sci-fi story with a GPT-2-based text generation model. The tool uses a "turn-taking" approach (Figure 1) where the user starts with writing the beginning the story. The model then continues the story by generating a section that follows the user's previous one. The user and the model continue each writing a section in turns until the end of the story. The user may also edit the AI-generated section or regenerate a section when they are not satisfied with the AI-generated result.

## 3.1. The Web Interface

The web interface of our tool was implemented using the Django framework. As shown in2, two different interfaces are designed for two modes. "Edit Mode" and "No Edit Mode" both have a "Submit" button for the human user to submit their written text, a "Regenerate" button for the AI model to regenerate sentences, and an "End" button to end the story. There is also an "Edit" button for the user to edit the text generated by the AI model (the Edit button was disabled in the "No Edit" condition in the study). All history texts will be shown at the top of the page, with human-written texts in black and machine-generated texts in red. The back button allows the user to go back to their last operation.

When the user clicks on the "Regenerate" button, the model re-selects a random seed, and uses the model to generate its last paragraph. This feature allows the user to quickly get a new AI-generated paragraph when the previous one was not desirable, such as when the model fails to generate readable text, generates repetitive text, or switches topics abruptly.

## 3.2. The Text-Generation Model

Our prototype tool uses a GPT-2 language model that was fine-tuned to a sci-fi theme. GPT-2 is a super-large-scale language model proposed by OpenAI in 2019 [33, 34]. We used the "medium" version of GPT-2 with 355M parameters. In order to adapt the style of generated text to the sci-fi domain used in the study, we fine-tuned GPT-2-medium to the field of science fiction. We used the Sci-Fi Stories Text Corpus [12] collected by Robin Sloan as the dataset for fine-tuning GPT-2-medium. The GPT-2's finetune function was called. The step and the learning rate was set as 1500 and 1e-5, respectively. Most of the science fiction story data in it come from *Pulp Magazine Archive*.

# 4. Preliminary User Study

In this study, we ask the three research questions (RQs) below:

- RQ1: What patterns of interactions are taken up by humans when they interact with machines in collaborative writing?
- RQ2: How does the ability to select, edit, and cut out machine-generated text affect the human-machine co-writing process?
- RQ3: How do humans perceive the role of the machine in the editable vs. non-editable interaction modes?

## 4.1. Procedure

To answer these RQs, with the tool described in Section 3, we conducted a user study to investigate the dynamics of human-AI interaction in fiction co-writing. The study uses a within-subject design, where each user had to use both the "Edit Mode" (where editing the AI-generated text was enabled) and the "No Edit Mode" (where editing the AI-generated text was disabled) when writing with the tool. The order of the two conditions was random. In each study session, following a short demonstration of the user interface and the theme that they would write about, the user was asked to write the beginning of a sci-fi story about humans finding a new home in space. Using this beginning, the user then wrote a 5-paragraph story with our tool in the first condition. After this, the user filled out a usability questionnaire and had a 5–10-min semi-structured interview about their experience in the first condition. Similarly, the user then wrote another story, filled out the questionnaire, and had an interview in the second condition.

We post advertisement on the university's bulletin and recruited nine participants (n=9) for our study, later referred to U1 to U9 in this paper. Participants were all graduate students who were interested in human-machine co-writing. 5 of them were 18–25 years old, and 4 of them were 26–35 years old. 5 of them used English as their first language, and 4 of them used Chinese as their first language. 8 of them were males, and 1 of them was female. All users had some creative writing experiences. 2 were novices, 3 had intermediate-level of experiences, and 4 were experienced fiction writers.

Each user's screen recording of their writing process, questionnaire, and interview was recorded and tran-

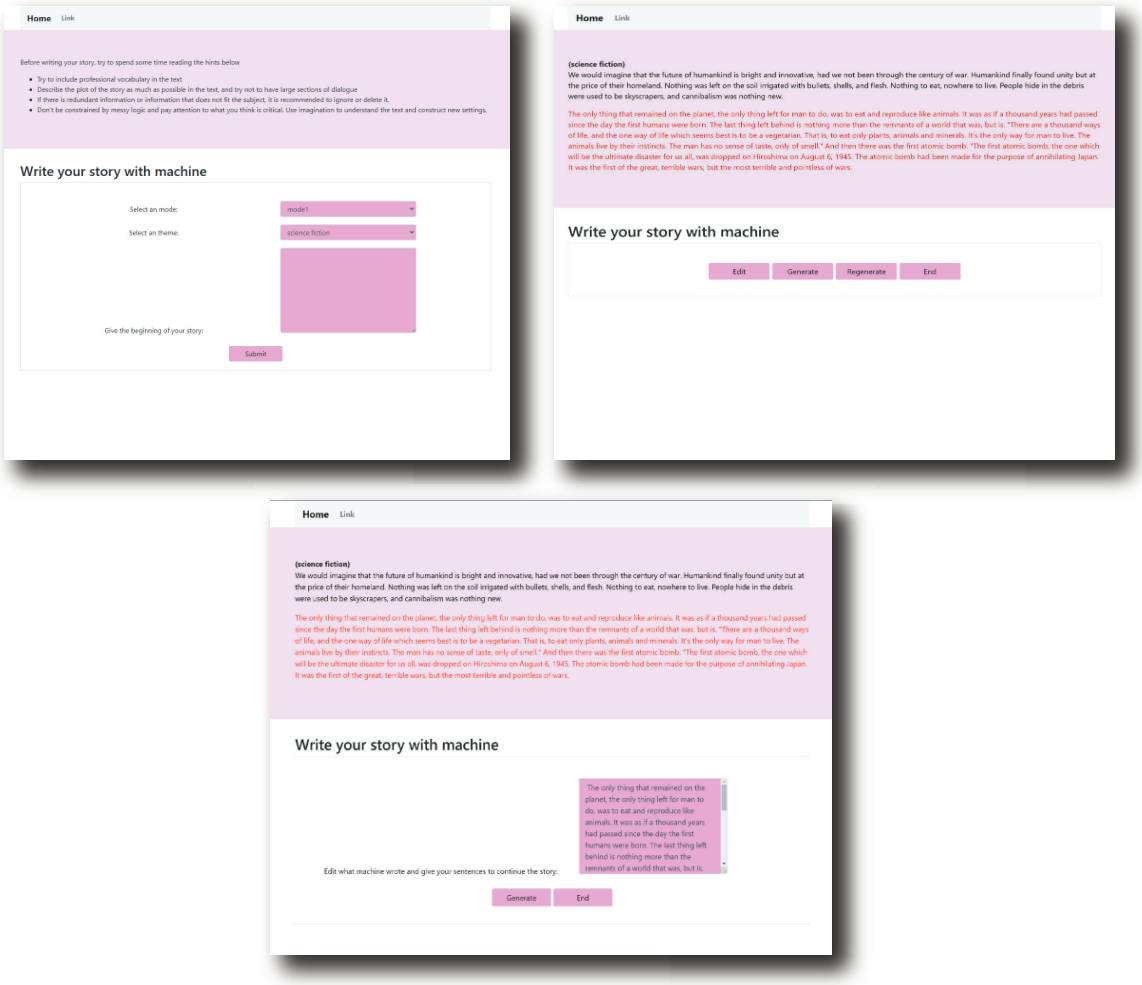


**Figure 2:** The user interface of our collaborative creative writing tool used in the study.**Top Left**:The initial interface includes writing prompts, mode selection, theme selection, input box, and submit button. **Top Right**:In the upper interface, the black font represents the text entered by the user, while the red font represents the text generated by the AI model. After the AI model generates the text, the user can choose to modify, to regenerate, to skip the modification to continue generating, or to end the interaction. **Bottom**:The user can modify the text generated by the AI model.

scribed. Users were asked to think aloud while writing. One of the experimenters conducted open coding analysis [35] of the written contents, think-aloud, and interview transcripts for the qualitative results.

## 5. Descriptive Statistics of the Stories

In the "Edit Mode", users usually spent 4–10 minutes writing a beginning of a sci-fi story that had an average length of 117 words [M=117, SD=56]. After 20–30 minutes' writing, the users would finish the story that had an average length of 622 words [M=622, SD=109], in which 320 words were written by the user [M=320, SD=106], and 302 words were written by the machine [M=302, SD=28]. In the "No Edit Mode", it took 4–10 minutes for users to write another beginning of a sci-fi story that had an average length of 117 words [M=106, SD=51]. After that, users spent 20–40 minutes completing the the story with an average length of 599 words [M=599, SD=127], where 282 words were written by users [M=282, SD=125], and 317 words were written by the machine [M=317, SD=31].

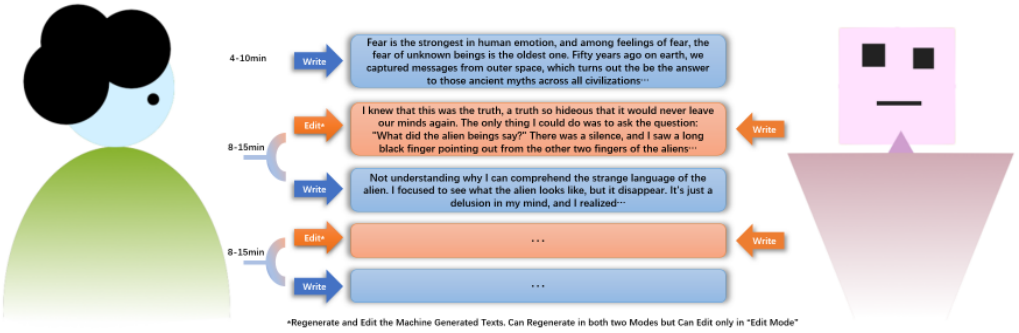


**Figure 3:** The Task flow of our study. The user and the AI takes turns to co-write a short science-fiction story. The user starts with writing the beginning (Paragraph 1) of a sci-fi story of human beings finding new homes. The AI model generates the Paragraph 2, which the user can regenerate, select, or edit the texts (in the "Edit Mode" condition). The user and the AI repeats this process to write Paragraphs 3 and 4 and finally the user ends the story with the Paragraph 5.

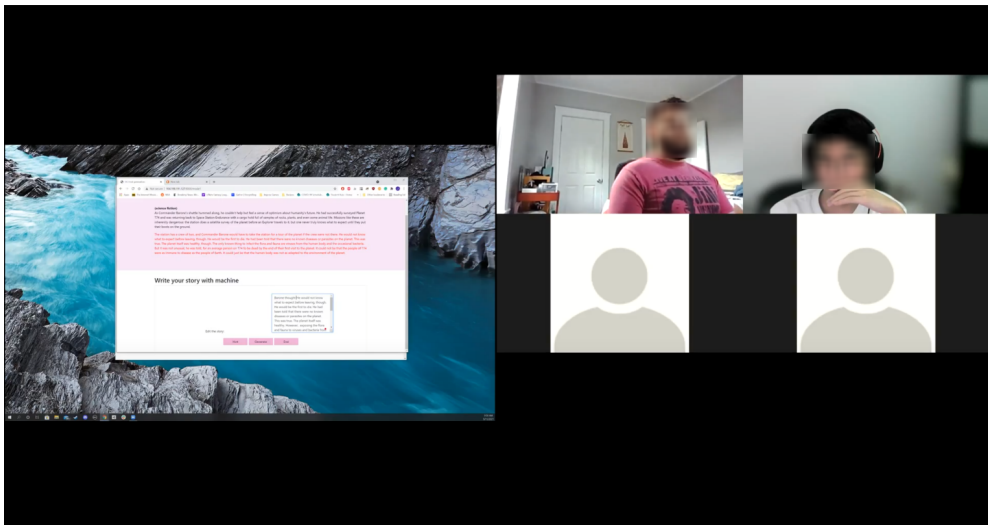


**Figure 4:** Screenshot of the experiment. **Left:** The user shares his screen. At this time the user is editing the text generated by the machine. **Right:** The user is in the upper left corner and the other three are researchers.

## 6. Qualitative Findings

In this section, we describe the properties of the co-written story and user's strategies for co-writing with the AI-enabled tool. Specifically, we investigated what was their reaction towards the AI-generated texts in two different modes, how AI-generated texts affected their creative writing process, and how they perceived the partnership between them and the AI-enabled tool in two different modes of writing.

### 6.1. Story Content

By coding the stories, we found that new twists, including new characters, new scenes, and new events were more frequently found in AI-generated texts (after regeneration, if any) than user-written texts. For example, in U4's "Edit Mode" story. U4 only mentioned "*We*" as a new character, "*uncertain terrain*" as a new scene, "*We are currently approaching a new solar system with a planet that seems inhabitable.*" as a new event in paragraph 1. However, the machine wrote in both paragraph 2 and "*a*

*man*", "*Icter*" as additional characters, "*winding corridor*", "*a tunnel*", "*a dimly lit room*" as new scenes, and "*walking down*", "*a man stood in front of me*", and "*should walk back and tell the others*" as new events. Surprisingly, users considered the unexpectedness as the core inspiration or reason of continuing their writing, and took good use of the new elements to continue the story, such as U4 wrote "*The others look at me inquisitively, wondering what was in the structure, and glad that I had made it out alright. I said 'there was a man.'*" in paragraph 3 after reading machine texts "*should walk back and tell the others*" in paragraph 2.

Notably, the AI model would sometimes suddenly change the positive atmosphere in previous paragraphs into a negative atmosphere, or the other way around. For example, U2 wrote an optimistic beginning that "*As Commander Barone's shuttle hummed along, he couldn't help but feel a sense of optimism about humanity's future. He had successfully surveyed Planet T74 and was returning back to Space Station Endurance with a cargo hold full of samples of rocks, plants, and even some animal life.*", but the machine suddenly turned the story into a negative description that "*He had been told that there were no known diseases or parasites on the planet.*" (U2 "Edit Mode", user and machine wrote in paragraph 1 and 2).

Despite having many unexpected elements, user-written texts and the selected AI-generated texts were coherent with each other. The selected AI-generated texts often use events, characters, and scenes that were mentioned in user-written paragraphs. For instance, since U2 had written "*However, one day an accident at the factory would force AB67 to do something extraordinary.*", the machine continued the plot with "*And the result is this: a new robot, the first fully-autonomous, self-repairing, self-replenishing, fully-reactive, self-repairing robot.*", and mentioned the user-made entity "*AB67*" in "*AB67 had been the first fully self-repairing robot.*" (U2 "No Edit Mode", user and machine wrote in paragraph 1 and 2).

## 6.2. Strategies for Interaction with AI-generated Texts

By coding the think-aloud scripts and interview transcripts, we found that users' reactions to the text generated by the AI model and their strategies of utilizing them can be classified into two different groups by their expectation of the story: having clear and explicit intent about what they wanted to write (referred to as DI group) and having only implicit implied intent about what they wanted to write (referred to as II group).

Most users had concrete ideas about the story, saying like "*As in my mind. Earth is destroyed.*"(U2 in "Edit Mode"). By contrast, the users who had only implied intent would say like "I don't think about the ending "(U1 in "Edit Mode"). Users who had different expectations performed differently in the same condition, and users who had similar expectations also performed differently in two conditions.

### 6.2.1. Reaction to the Coherence of AI-generated Texts

Users in the II group had lower coherence expectation of the AI-generated texts than users in the DI group. And they all had higher expectation of coherence when they were in the "No Edit Mode".

Users in the II group prefer the model to generate texts that contain some new entities that they could work on. For example, any new characters, events, or locations could be good for them: "*I don't think I said anything about a name so I guess it named somebody, which is cool.*" (U4 in "Edit Mode").

However, users in the DI group were trying to find something that logically fitted into their story in the AI-generated texts. For example, some expected subjects to have logical continuations such as "*I guess it depends first on what I wrote and then if I think it's a logical continuation.*" (U1 "No Edit Mode"), and refused illogical characters such as "*Machine starts spitting out more and more characters that were not mentioned in the scene which made it really wonky later on.*" (U5 "Edit Mode"). Additionally, they wanted the AI model to continue the story as they expected, such as "*Well I expected the machine to basically take, you know, to see what I wrote and can expand upon it or relate to it in some way that's what I expected.*" (U5 "Edit Mode"). However, they would be more excited if some unexpected items that logically fitted to their story were found in the generated text, like meeting with an unexpected plot: "*And they took it even one step further with like, Okay, what if you peel off his skin.*" (U2 "No Edit Mode").

In the "Edit Mode", users in both groups would accept text that contained parts that they could use, like "*And if there are some sentences can use, you will definitely work, work, work on it.*"(U1 "Edit Mode"), or "*But I can work with these first three sentences.*"(U2 "Edit Mode"). However, in the "No Edit Mode", users would expect the text to fully meet their expectations on coherence, like "*I think I definitely wanted something that flowed a bit better with a story, but with the first one, I was more okay with giving me something that perhaps added new ideas.*" (U3).

### 6.2.2. Reaction to the Unexpectedness of AI-generated Texts

Users were amused when unexpected texts appeared, even if they presented random events or characters that had no relationship to what users had written. For example, U2 laughed when he saw his story turned into a Christmas story, but regenerated it by saying "*This is*

*not a Christmas story.*" (U2 "No Edit Mode"). The unexpectedly redundant texts also amused users. For example, U4 laughed when encountering sentences like "*I was a human with a human face.*" in the story, and U5 laughed when saying "*That's a very odd sentence 'the man in the open suit it wasn't a woman', very weird.*" (U5 "Edit Mode").

Meeting with unexpectedness, users applied some of the AI-generated texts that was easy to work with. In most situations, redundant texts were too hard to work with: "*I'm trying to like get some notes that fit a little bit more and gives the idea about how to drive the plot forward but it seems to like to be redundant.*" (U5 "Edit Mode"). But there was one exception in U4's writing: "*I guess like the only way to make that sentence makes sense ('I was a human with a human face'), is if it wasn't redundant, the story could be that he didn't always have a human face.*" (U4 "Edit Mode"). Even when the text was not redundant, it could still be hard to work on when the plot was being driven forward too quickly: "*I'm going to regenerate it because it focuses so much on death and yet I don't want it to be like at the start of the story.*" (U2 "Edit Mode"). However, this situation could be mitigated or even be useful if the machine wrote the ending: "*I feel like it wrote a decent ending on its own and didn't really want to add anything to it.*" (U5 "No Edit Mode", in delight tone).

#### 6.2.3. Reaction to the Fluency of AI-generated Texts

Fluency of machine texts was more important in the "No Edit Mode" than the "Edit Mode". In the "Edit Mode", for most of the users, partial readability would be sufficient for the requirement on fluency because "*if you're able to edit it and then it's less important because you can just fix it up a little bit of it.*" (U1). In "No Edit Mode", the expectation on fluency becomes as important as the coherence for most users, such as "But if you can't (edit), then it's kind of more important that it is fluent." (U1).

#### 6.2.4. Reaction to Editing

All users agreed that at least some basic edits of AI-generated texts should be allowed to make them more useful. The most common reason is along the lines of: "*This one is definitely harder because oftentimes there would be a good amount of it that would be useful and like I would want to keep writing off of. But then there's also be sections like a piece of sentences that were not greatly helpful.*" (U3 "No Edit Mode"). Even if some of the texts in "No Edit Mode" had high quality and met the basic expectations of users, most users still felt editing was necessary, like *"I think some editing would be required because, You know, there's still some consistencies but not as glaring as that in first mode texts.*" (U5 "No Edit Mode").

U4 and U8 preferred edits that do not affect the continuation of the story. In the interaction flow, they preferred to refine on the fluency of the writing after the whole story has been generated. U4 said, "*I wouldn't really change the story it comes up with but I would just change or delete a few sentences or something.*" (U4 "Edit Mode").

Although all users agreed that editing was essential, U6 preferred not to edit the text because editing was a burden: "*In the first mode ('Edit Mode'), I must understand the machine texts and then edit them. But in the second mode ('No Edit Mode'), I don't need to understand them and just choose one of my favorite and continue the story.*" (U6).

## 7. Discussion

The language model's limitation made it unpredictable. It sometimes provides low-quality texts full of words that could hardly make sense. At other times, it provides high-quality inspirations that move the plot forward beyond humans' expectation. Such unexpectedness accounted for the unique interaction pattern of human-AI co-writing in this study. Corresponding to previous quantitative findings [36], the qualitative results in this paper showed that users considered the coherence of the machine-generated texts as a priority. The users' attitudes towards unexpected but coherent elements generated by the AI model further suggested that users expected the model to provide them with surprising inspirations. However, due to the repetition caused by the model over-confidence problems [24], users could only get such paragraphs occasionally by chance. The AI generating process was not transparent and there was a lack of user control, and thus users could not expect the next batch of generated text to be better than the previous one. The low probability of getting useful pieces from the model would frustrate users and make them compromise on the incoherent and tenuous text that conveyed merely inspiration.

Nevertheless, the unexpectedness of machine-generated texts should be highlighted in an ideal human-AI co-writing tool. After being selected and refined by human writers, such unexpected but logical elements could make the story more exciting than writers' previous intention. From findings in our study, this could not only serve as a dramatic contradiction in the story but also as motivations for users to keep writing. In the design of the tool, it would be useful to facilitate the user's utilization of the unexpected elements as their wish (e.g. provide users with options of editing machine-generated texts in the system). This could help to reduce the frustration brought by unpredictable repetitions and occasional bad fluency. However, even the design of the interaction modes could

mitigate such frustration, the algorithm should also be improved. Better quality in AI-generated texts could allow users to focus more on the ideas conveyed by AI-generated texts rather than spending most of the time on regenerating and fixing the coherence and fluency of AI-generated texts.

The users' different perceptions of AI's roles in the co-writing process suggested different interaction patterns. In the study, most users perceived the machine as an active idea generator. They preferred the "Edit Mode" more since they could pick what they liked regardless of the fluency and coherence of the texts. Thus, it was important to make them able to edit both machine texts and their texts at any time in the writing process. Furthermore, more user-controllable variables can be added into the tool for them to allow finer-grained user control of the generation process. For example, the tool could allow users to control the ideal length of the generated text, the scenes, the atmosphere of the plot, or some weights that could help the model focus more on certain important parts of the user texts. Some users, on the other hand, wished the machine to be a human writing assistant. In this case, the machine should be able to accept both previous paragraphs and following paragraphs as inputs to connect the user-defined milestones in the story for them. Several works were focused on short sentence infilling [37, 38], but long paragraphs infilling still remains to be explored.

Besides, some users regarded the AI-enabled tool as an active co-writer or a writing exerciser. They tried to keep the initial output of the machine texts regardless of its coherence and fluency. They enjoyed all the unexpectedness of the machine-generated texts and wish not to intervene in the generating process. In this case, the texts were expected to be uncontrollable. However, the definition of good quality of texts could be vague in this mode of interaction, since even the redundancy could be interpreted as metaphors. More research should be conducted to develop a good co-writing or writing exercise machine.

In summary, the future active AI writing tools should strengthen AI's strong ability of producing high quality unexpectedness. And they should allow users to utilize such unexpectedness efficiently. The "Regenerate" and the "Edit" function mentioned in this paper should be the core. The goal of the "Regenerate" is to ensure users to find what they want as they wish as fast as possible (reduce the compromises). To accomplish this goal, for example, the future interface can display multiple outputs simultaneously[13, 10] and enable users to control more parameters to regenerate the texts. It could also ask users to grade the outputs and learn from their writing (use users' inputs as fine-tune datasets)[36]. For the "Edit" function, the tool should be integrated into a text editor such as *Microsoft Word* for users to both edit and save their work in a professional way. The AI should act as an writing assistant with a customized avatar on call who eventually become essential in users' writing process.

## 8. Conclusion

In this paper, we reported preliminary findings on how 9 users interacted with a "turn-taking" style human-AI co-writing tool to write short science-fiction stories. We discovered that different mental expectation of users could affect their strategies and their perception of the machine's role in the co-writing process. The AI-enabled tool was used as an active idea generator, a co-writer, or a writing assistant in different scenarios by different users. We discussed the challenges in managing the trade-offs in the desired level of unexpectedness in generated story plots, the coherence and fluency of AI-generated texts, the appropriate level of user-control, and the future interface design.

## Acknowledgements

This research was supported in part by a Google Cloud Research Credit Grant, a Hong Kong Arts Development Grant, and an Asia Research Collaboration Grant from Notre Dame International.

## References

[1] C. Oh, J. Song, J. Choi, S. Kim, S. Lee, B. Suh, I lead, you help but only with enough details: Understanding user experience of co-creation with artificial intelligence, in: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, 2018, pp. 1–13.

[2] N. Davis, C.-P. Hsiao, K. Yashraj Singh, L. Li, B. Magerko, Empirically studying participatory sense-making in abstract drawing with a co-creative cognitive agent, in: Proceedings of the 21st International Conference on Intelligent User Interfaces, 2016, pp. 196–207.

[3] K. I. Gero, L. B. Chilton, Metaphoria: An algorithmic companion for metaphor creation, in: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, 2019, pp. 1–12.

[4] M. Guzdial, N. Liao, J. Chen, S.-Y. Chen, S. Shah, V. Shah, J. Reno, G. Smith, M. O. Riedl, Friend, collaborator, student, manager: How design of an ai-driven game level editor affects creators, in: Proceedings of the 2019 CHI conference on human factors in computing systems, 2019, pp. 1–13.

[5] J. Koch, A. Lucero, L. Hegemann, A. Oulasvirta, May ai? design ideation with cooperative contex-

tual bandits, in: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, 2019, pp. 1–12.
[6] R. Louie, A. Coenen, C. Z. Huang, M. Terry, C. J. Cai, Novice-ai music co-creation via ai-steering tools for deep generative models, in: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, 2020, pp. 1–13.
[7] M. Suh, E. Youngblom, M. Terry, C. J. Cai, Ai as social glue: Uncovering the roles of deep generative ai during social music composition, in: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 2021, pp. 1–11.
[8] C.-Z. A. Huang, H. V. Koops, E. Newton-Rex, M. Dinculescu, C. J. Cai, Ai song contest: Human-ai co-creation in songwriting, arXiv preprint arXiv:2010.05388 (2020).
[9] P. Karimi, J. Rezwana, S. Siddiqui, M. L. Maher, N. Dehbozorgi, Creative sketching partner: an analysis of human-ai co-creativity, in: Proceedings of the 25th International Conference on Intelligent User Interfaces, 2020, pp. 221–230.
[10] A. Coenen, L. Davis, D. Ippolito, E. Reif, A. Yuan, Wordcraft: a human-ai collaborative editor for story writing, arXiv preprint arXiv:2107.07430 (2021).
[11] M. Kreminski, M. Dickinson, M. Mateas, N. Wardrip-Fruin, Why are we like this?: The ai architecture of a co-creative storytelling game, in: International Conference on the Foundations of Digital Games, 2020, pp. 1–4.
[12] R. slogan, Writing with the machine, https://www.robinsloan.com/notes/writing-with-the-machine/ (2016).
[13] E. Clark, A. S. Ross, C. Tan, Y. Ji, N. A. Smith, Creative writing with a machine in the loop: Case studies on slogans and stories, in: 23rd International Conference on Intelligent User Interfaces, 2018, pp. 329–340.
[14] C. Shu, Y. Zhang, X. Dong, P. Shi, T. Yu, R. Zhang, Logic-consistency text generation from semantic parses, arXiv preprint arXiv:2108.00577 (2021).
[15] A. Krishna, S. Riedel, A. Vlachos, Proofver: Natural logic theorem proving for fact verification, arXiv preprint arXiv:2108.11357 (2021).
[16] W. Fedus, I. Goodfellow, A. M. Dai, Maskgan: better text generation via filling in the_, arXiv preprint arXiv:1801.07736 (2018).
[17] Y. Zhang, Z. Gan, K. Fan, Z. Chen, R. Henao, D. Shen, L. Carin, Adversarial feature matching for text generation, in: International Conference on Machine Learning, PMLR, 2017, pp. 4006–4015.
[18] D. Buschek, M. Zürn, M. Eiband, The impact of multiple parallel phrase suggestions on email input and composition behaviour of native and non-native english writers, in: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems, 2021, pp. 1–13.
[19] O. Schmitt, D. Buschek, Characterchat: Supporting the creation of fictional characters through conversation and progressive manifestation with a chatbot, in: Creativity and Cognition, 2021, pp. 1–10.
[20] M. Guzdial, M. Riedl, An interaction framework for studying co-creative ai, arXiv preprint arXiv:1903.09709 (2019).
[21] M. Jacob, B. Magerko, Interaction-based authoring for scalable co-creative agents., in: ICCC, 2015, pp. 236–243.
[22] Y. Lin, J. Guo, Y. Chen, C. Yao, F. Ying, It is your turn: collaborative ideation with a co-creative robot through sketch, in: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, 2020, pp. 1–14.
[23] A. Elton-Pym, Principles for ai co-creative game design assistants, in: Proceedings of the AAAI Conference on Artificial Intelligence and Interactive Digital Entertainment, volume 16, 2020, pp. 335–336.
[24] A. See, A. Pappu, R. Saxena, A. Yerukola, C. D. Manning, Do massively pretrained language models make better storytellers?, 2019. arXiv:1909.10705.
[25] T. Liu, K. Wang, L. Sha, B. Chang, Z. Sui, Table-to-text generation by structure-aware seq2seq learning, in: Thirty-Second AAAI Conference on Artificial Intelligence, 2018.
[26] A. Fan, M. Lewis, Y. Dauphin, Hierarchical neural story generation, arXiv preprint arXiv:1805.04833 (2018).
[27] M. Rose, Rigid rules, inflexible plans, and the stifling of language: A cognitivist analysis of writer's block, College composition and communication 31 (1980) 389–401.
[28] B. Kostka, J. Kwiecieli, J. Kowalski, P. Rychlikowski, Text-based adventures of the golovin ai agent, in: 2017 IEEE Conference on Computational Intelligence and Games (CIG), IEEE, 2017, pp. 181–188.
[29] T. Atkinson, H. Baier, T. Copplestone, S. Devlin, J. Swan, The text-based adventure ai competition, IEEE Transactions on Games 11 (2019) 260–266.
[30] N. Fulda, D. Ricks, B. Murdoch, D. Wingate, What can you do with a rock? affordance extraction via word embeddings, arXiv preprint arXiv:1703.03429 (2017).
[31] M. Hausknecht, R. Loynd, G. Yang, A. Swaminathan, J. D. Williams, Nail: A general interactive fiction agent, arXiv preprint arXiv:1902.04259 (2019).
[32] A. Calderwood, V. Qiu, K. I. Gero, L. B. Chilton, How novelists use generative language models: An exploratory user study., in: HAI-GEN+ user2agent@ IUI, 2020.

[33] A. Radford, J. Wu, R. Child, D. Luan, D. Amodei, I. Sutskever, et al., Language models are unsupervised multitask learners, OpenAI blog 1 (2019) 9.

[34] S. Dathathri, A. Madotto, J. Lan, J. Hung, E. Frank, P. Molino, J. Yosinski, R. Liu, Plug and play language models: A simple approach to controlled text generation, arXiv preprint arXiv:1912.02164 (2019).

[35] S. H. Khandkar, Open coding, University of Calgary 23 (2009) 2009.

[36] N. Akoury, S. Wang, J. Whiting, S. Hood, N. Peng, M. Iyyer, Storium: A dataset and evaluation platform for machine-in-the-loop story generation, 2020. arXiv:2010.01717.

[37] C. Donahue, M. Lee, P. Liang, Enabling language models to fill in the blanks, 2020. arXiv:2005.05339.

[38] D. Ippolito, D. Grangier, C. Callison-Burch, D. Eck, Unsupervised hierarchical story infilling, in: Proceedings of the First Workshop on Narrative Understanding, 2019, pp. 37–43.