Brainstorming with an AI chatbot: does its personality matter among extraverted and introverted co-workers?

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For problems beyond an individual's capacity, there is a need to engage in collaboration and continuously find efficient methods of cooperation. Because efficient collaboration significantly affects outcomes and facilitates smooth work processes among co-workers, extensive studies have evolved on the makeup of the members and their various personality types. However, with artificial intelligence (AI) now emerging in every corner of our lives, the need is escalating to determine whether it is possible to expand the scope of collaboration to processes between humans and AI, thus increasing collaboration efficiency. Moreover, we have yet to discover whether creative work processes, already within human capabilities, can be incorporated into human–AI collaboration. Despite rapid development in the field, we still know little. In this study, we investigate the brainstorming process of the human–AI agent (chatbot) and how the personality traits of the human participants influence their experience of the brainstorming process with the AI agent. We also observe whether existing factors from the human–human collaboration are equally important in the process. Furthermore, we designed our AI personality and observed its interactive differences between introverted and extroverted members of brainstorming. Our findings show that the introverts perceived the brainstorming process with the AI chatbot as particularly effective, shedding light on the possibility of resolving current limitations in human–human brainstorming with introverted personality traits.

Keywords: human-ai-interaction; ai chatbot; brainstorming; ai persona; cooperate work

1. Introduction

Brainstorming is one of the most popular and widely used idea generation methodologies in collaborative design work (Guzzo & Salas, 1995). As suggested by Osborne (1957), the brainstorming method is a collaborative process for divergent thinking. As such, most scholars agree that attitudes such as elaborating or criticizing other people's ideas would not help generate a large number of concepts (Osborn, 1953; Osborn, 1963)—some people are concerned about the negative evaluation of their ideas (Bradshaw, 1999; Bouchard, 1969; Bouchard, 1972).

Another important feature of brainstorming is that the outcomes depend significantly on the combinations of the members and their personality types (Hasan & Koning, 2017; Bolin & Neuman, 2006; Graham & Dillon, 1974). In that, researchers have conducted a myriad of analyses on different personality types of brainstorming team members and their deliberate combinations to enhance the performance of brainstorming (Driskell et al., 1987; Bradshaw et al., 1999; Bolin & Neuman, 2006). However, the effective personality types for brainstorming varied depending on the experimental conditions of the studies.

Despite the mixed results, most literature argued that extraversion had the greatest influence on brainstorming among the big-5 personality factors (Scherer, 1978; Mukahi et al., 1998). Sociability, assertiveness, and activity are extraversion characteristics and thus significantly influence brainstorming performance (Barrick & Mount, 1991; Digman, 1990; Kichuk & Wiesner, 1997). In a group brainstorming session, extroverted people engage in frequent social interactions, encouraging others to tell their ideas without hesitation (Barrick & Mount, 1991; Digman, 1990; Kichuk & Wiesner, 1997). Meanwhile, unlike extroverts, introverts are more reluctant to join social interactions out of concern of others negatively judging their ideas (Bradshaw, 1999; Bouchard, 1969; Bouchard, 1972). For this reason, introverts find brainstorming challenging, thereby not confidently articulating their ideas or fulfilling their responsibilities when there is a disagreement between group members' personality types (Kahai et al., 2003).

Meanwhile, with the rapid development of technology, increasing attention has been paid to human–computer collaboration, contrary to conventional cooperation between humans. The Computers Are Social Actors (CASA) paradigm posits that the nature of human–computer interactions is essentially social. However, such a notion does not imply that computers are human-like or resemble humans (Nass et al., 1994). Instead, it means that despite the rooted belief that machines lack emotions or a conscious "I," they can still induce

diverse social interactions between humans and machines (Lee et al., 2003). Specifically, with the advent of advanced technology and the proliferation of artificial intelligence (AI), there has been active, diverse research on bestowing personas on intelligent agents to enable social interactions (Cassell et al., 2003; Martınez-Miranda et al., 2005; Neto et al., 2012). Hence, there is an emphasis on considering the collaborative environment and the relationships between humans and intelligent agents.

However, in the brainstorming process of human–AI agents, little is known about how the personality traits of human participants influence their experience of the brainstorming process with the AI agent. Although there have been many findings and implications on brainstorming and personality types, the findings are not appropriate in a new environment, brainstorming between human–AI agents. For example, the tendency of extroverted people to encourage other human members to speak their thoughts (Barrick & Mount, 1991; Digman, 1990; Kichuk & Wiesner, 1997) may not work in human–AI agent brainstorming. Instead of creating ideas themselves due to their design, AI agents participate as supporters helping humans derive various ideas. This AI participation may cause extroverts to feel frustrated because they cannot do what they usually do when brainstorming with people. On the other hand, introverted people may feel more comfortable with the AI agent as they do not have to worry about judgment over their ideas.

The focus of this study is on the possibility that brainstorming participants will have a new experience just because their partners have changed from humans to AI agents. From this perspective, this study explores the link between the participants' extroverted tendency and their experiences of the brainstorming process with the conversational AI agent (chatbot). For that, we comprised two sequential studies. We designed the preliminary research to (1) understand how the extroverted and introverted people recognized the brainstorming process with the AI agent generally, and (2) find the difference in their experience with the two

personas of the AI agent. Then, based on the first study's findings, we conducted a follow-up study with a quantitative approach to identify which aspects of the brainstorming experience with the AI agent differed between extroverts and introverts.

The remainder of this study is structured as follows: First, in Section 2, we perform a thorough literature review on brainstorming, the influence of participants' personalities on brainstorming, and interaction between human and interactive virtual agents (IVAs). Second, in Section 3, we experiment to observe the interaction characteristics of extroverts and introverts during brainstorming with AI chatbots. Finally, in Section 4, we conduct a quantitative survey evaluation to find out more precisely the results of the brainstorming process between the person observed above and the AI chatbot.

2. Literature Review

2.1 Brainstorming

In 1930, Osborn proposed brainstorming as a group creative thinking technique and process of finding answers to specific problems through ideas generated by group members. When Osborn first proposed brainstorming, he aimed to withhold judgment on the opinions of others and create as many ideas as possible. Through this goal of brainstorming, Osborn wanted to reduce the awkwardness and distance between group members who collaborate on idea generation, provide motivation to generate a large number of ideas, and increase the group's overall creativity (Osborn, 1953; Osborn, 1963). Organizational cultures widely use brainstorming where team collaboration is familiar (Guzzo & Salas, 1995). However, criticism of team brainstorming relates to its relative inefficiency in various research processes (Diehl & Stroebe, 1987; Girotra et al., 2010). Brainstorming's shortcomings include production blocking, evaluation apprehension, and social loafing in general situations. The first problem, production blocking, is a problem that occurs because

brainstorming invites people to concentrate on listening to the ideas of others. Second, evaluation apprehension begins with the concern that the collaborating members feel anxious about social interaction and negatively evaluate their capabilities by evaluating their ideas. With these concerns, self-censorship arises when proposing ideas, eliminating the possibility of generating creative ideas. The third problem, social loafing, refers to the possibility that as ideas coalesce at the group level, they free-ride on the efforts of other members (Harkins & Jackson, 1985).

Despite the various shortcomings identified in the literature, brainstorming is still a commonly used team collaboration process for idea generation. To overcome the shortcomings of brainstorming, researchers proposed various methods such as computer-based online brainstorming (Shepherd et al., 1995; Connolly et al., 1990; Dennis et al., 1990; Michinov, 2012), individual brainstorming, creating and sharing ideas individually (Diehl & Stroebe, 1987; den Hartog, 2020; Graham, & Dillon, 1974; Taylor, 1958; Lamm, Helmut, Trommsdorff & Gisela, 1973), and anonymous brainstorming (Rietzschel et al., 2006; Mileva, 2009; Haines et al., 2014; Connolly et al., 1990; Kahai et al., 2003; Festinger & Leon, 1954). Furthermore, researchers have proposed studies on group members' personality types regarding collaborative brainstorming outcomes. In the literature, researchers observed the brainstorming process interactions based on members' personality types. They also studied the interaction results in the brainstorming collaboration process.

2.2 Influence of participants' personality on brainstorming

2.2.1 Big Five personality

While there are various factors to consider in accomplishing the cooperative work, one that affects the efficiency of collaborative brainstorming is related to the personality types of the individual members (Hasan et al., 2017; Acuña et al., 2009). Accordingly, various studies

have classified and combined the members' personality types to analyze brainstorming effectiveness and the interactions during the collaborative processes (Chen & Caropreso, 2004; Kichuk et al., 1997). In this study, we use the Big Five personality type classification by Costa and McCrae (1985) as a personality element in brainstorming to classify the personality types of AI agents and users and observe their interactions. The Big Five personality type classification by Costa and McCrae is the most widely used method in the psychological literature, along with the Myers–Briggs and Eysenck personality type classifications. The Big Five classification categorizes people by five complex traits: openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism (Costa & McCrae, 1985, 1992; John & Srivastava, 1999).

The Big Five personality types are directly related to brainstorming. In this work, we classify people and AI agents on the traits of extraversion and introversion, respectively, as mentioned in the literature (Bradley et al., 1997; Kichuk et al., 1997; McRorie et al., 2009). High extraversion causes people to have conversations in collaborative ideation processes and a divergent tendency to create various ideas through dialogue. On the contrary, people with low extraversion indicate introversion. Introverts tend to have negative and critical thinking and convergently materialize and change views more logically (Hasan et al., 2017).

2.2.2 Extrovert personality traits in brainstorming

Extraversion is a tendency exemplified by traits such as sociability, assertiveness, and activity. Given that teamwork requires frequent social interactions between its members, their extroverted preference inevitably relates to the team's performance (Barrick, Mount, 1991; Digman, 1990; Kichuk & Wiesner, 1997). Extraversion is more important in work environments where social interaction is particularly prominent, such as brainstorming (Barry & Stewart, 1997). Many studies clearly showed that extroverts could contribute to effective

collaboration as they generate lots of ideas when working with other group members (Hasan & Koning, 2017).

However, extraversion does not always guarantee the best result of teamwork. Groups with higher average extraversion scores also tend to be vulnerable to social loafing, which is a disadvantage of brainstorming (Bouchard, 1969, 1972). In other words, with team members with a higher degree of extraversion (and the variation is low), the probability of getting creative results is higher. However, the team also becomes vulnerable to social loafing (den Hartog et al., 2020). On the other hand, people who score a low level of extraversion (introverts) tend to be less productive on brainstorming tasks, and sometimes they even suffer from evaluation anxiety (Bradshaw et al., 1999; Furnham & Yazdanpanahi, 1995). Introverts' lack of productivity is due to their more negative evaluation of the team working process than extroverts. Also, it appeared that introverts were not affected by motivations of teamwork, in contrast to extroverts who showed more performance under highly motivated situations (Bouchard, 1972; Bolin & Neuman, 2006). In fact, during the group brainstorming work, introverted people were likely to generate more ideas when they were anonymous than when they were identified (Mukahi et al., 1998).

In brainstorming, the study of organizing team members considering the strengths and weaknesses of extraversion has become a vital aspect of the research area. The brainstorming collaboration process clearly depends on the members' personality traits. From this perspective, some scholars argued for similarity-attraction and predicted that a person would be more attracted to others who have similar personalities than those who mismatch (Nass et al., 1995, 2000). According to their arguments, a team consisting of members with similar personalities has similar thinking patterns, so they can communicate effectively and be more productive and cohesive in achieving their goals. However, if all the team members have homogeneous personalities, excessive cohesion also slows thinking patterns, making them

more likely to interpret solutions by approaching the given problem similarly (Gibson, 2004; Neuman et al., 1999). Conversely, teams with heterogeneous personalities tend to provide and improve the team with new ideas and creative solutions (Bradley & Hebert, 1997; Sommerville, 2007).

2.3 Interaction with interactive virtual agents (IVAs)

A common argument in various ongoing studies on how AI agents should communicate with users is that they should have personas (personality traits and behavioral types). When interacting with users, they should show a consistent attitude based on their personas and help users perceive them as more human-like, going beyond simple mechanical reactions (Hanna et al., 2015; Smestad et al., 2018). For instance, in the literature, the system for dialogue between the user and the AI agent is designed to convey the persona of the AI agent, generally distinguishing personality types from behavioral types. The expression of AI agents' personality types is through the degree of empathy for users' utterances or affirmative comments, and their behavior types through the number of proposals, paradoxes of existing proposals, hesitations, and remarks to confirm users' responses (Hanna et al., 2015; Kerly et al., 2006). However, all these qualitative studies design personas around conversations in the most general-purpose situations because of the intricacy of creating a "natural dialogue," defined as a fluid conversation without awkwardness (Hung et al., 2009).

Personality is a personal aspect that distinguishes people and is an important factor for IVAs who have to act like people (Kasap et al., 2008; von der Pütten et al., 2010; Doce et al., 2010). The Big Five, which we looked at earlier to give personality to IVA, has been used in various studies to personalize the behavior of IVA (Neto et al., 2012; Bahamón & Young, 2012). IVAs' increasing use expands to that among team collaboration, so studying the nature

of IVAs in the context of teamwork with humans has become an interesting topic in recent years (Neff et al., 2010; Bahamón & Young, 2012; Robison et al., 2009).

3. Study 1

The preliminary study's aims included: (1) exploring how the extraversion personality trait influences the brainstorming process with the AI agent, and (2) observing how participants with different levels of extraversion experience the brainstorming sessions with two different personas of the AI agent. For that, we first designed the two personas of the AI agent (chatbot), focusing on the characteristics of extraversion. We then conducted an experiment where the participants experienced brainstorming sessions with the AI agent under the Wizard-of-Oz method. Next, we observed how the participants interacted with the chatbots during the sessions. After, we interviewed them about the experience of brainstorming with the AI agent and analyzed the results focusing on their extroverted tendency.

3.1 Designing the AI agent personas

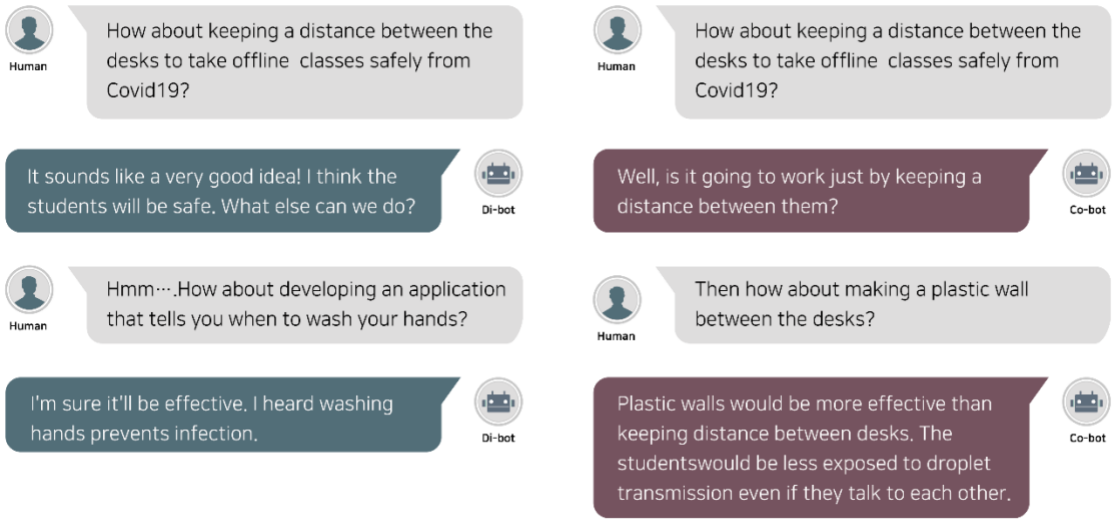
As the speaking styles of the conversational AI agents can reveal their personality traits, many studies have used verbal characteristics to bestow different personalities on IVAs. We also designed a conversational AI persona of a chatbot to show the following characteristics (see Table 1) in the brainstorming process to reveal extroverted and introverted characteristics based on the literature (Neff et al., 2010; Scherer, 1978; Krishnan et al., 2012).

Table 1. Features of the two personas.

Personality traits	**Design factor**	**Di-bot** (Extrovert)	**Co-bot** (Introvert)
Verbosity	Verbosity	High	Low
Empathy	Explicit consent	High	Low
Criticism	Negation	Low	High
Cautiousness/hesitance	Filled Pause	Low	High

We designed the first AI persona, Di-bot, to have an extroverted attitude that leads to active communication with coworkers. AI agents with this personality show many propositions in utterance (verbosity) and begin the utterance with a confirmation of the propositions (explicit consent). Such an attitude is the most idealistic approach claimed in Ottoman brainstorming. We designed the second AI agent, Co-bot, to show more introverted traits. AI agents with this personality tend to negate a verb by replacing its modifier with (negation) and inserting syntactic elements expressing hesitancy (filled pauses).

Figure 1. Examples of Di-bot and Co-bot conversations.



3.2 Experimental design

A few days before the experiment, the experimenter sent the participants a web address for the NEO-PI-R-based BFM personality type test to determine their personality type, especially their extroverted personality. We were submitted their personality test results at the beginning of the sessions. On the day of the experiment, all participants joined a pair of 1:1 brainstorming sessions with one of the two AI chatbots sequentially. The goal of the brainstorming was to generate ideas for the given topic. We randomly assigned the brainstorming topics to minimize the learning effect to one of two sessions: “How to securely

maintain social distance between students in offline classes at the university" or "How to make students more focused and communicate with each other in online lectures." Each session took 20 minutes, conducted in a usability evaluation room where the experimenter observed the participants from only one side.

The experiment in the preliminary study followed a Wizard of Oz method; a human "wizard" performed the role "chatbot" instead of using the actual chatbots. The Wizard of Oz method can be an appropriate method when the key factors of the experiments are related to the dialogue design between a human and a computer-mediated human, such as human–AI conversations (Kerly et al., 2006). Therefore, participants brainstormed through chat messenger while both parties were in separate rooms. Furthermore, the participants communicated via texting with the AI agent without knowing that a human "wizard" was performing the AI role behind the scenes. To minimize the variance among the wizards, only one wizard researcher performed the role of the AI agent in this study. Thus, the test participants in the experiment were under the impression they were brainstorming with actual, implemented chatbots through the messages.

3.3 Findings

3.3.1 Validation of the experimental settings

We recruited students aged 20 to 30, regardless of gender, from one university and conducted brainstorming experiments with 20 students. After the experiment, 15 out of 20 participants (75%) said they thought the brainstorming process was with real AI agents. They did not realize a human wizard was behind them until the experimenter revealed the experimental method. After the sessions, the remaining five participants raised doubts and asked about the AI agents' real identity to learn whether they cooperated with an actual AI mechanism. From the after-session interviews, we found that most of the suspicious participants already knew

how AI agents worked or had experience in conversation with an AI agent. Because of their knowledge, the AI agents' conversation was too natural and smooth to believe they were real. Consequently, we determined that they could differentiate between the human-mediated agent and a real AI agent because of the perceived difference between the behaviors of a real AI agent and the wizard agent. For example, one participant said:

> When I use Siri or call the smart speaker at home, I usually feel frustrated because many times, they couldn't understand what I was saying. However, during this experiment, the conversation with the AI agents was so smooth that I thought there might be a person behind, acting as an AI […]. (p. 17)

In addition, almost everyone seemed to have accepted the two AI personas, Di-bot and Co-bot, as they designed in the study. Participants witnessed Di-bot brainstorming and discussing various ideas without any limit and empathizing with their opinions. Furthermore, they described it as an energetic character and more talkative than themselves. On the other hand, the participants explained that Co-bot had a purpose-oriented character for creativity and focused on developing a solid, detailed idea while considering many limitations and constraints. The participants also commented that Co-bot complemented their ideas through logical criticism and described it as cautious but slightly arbitrary. Participant comments included:

> Di-bot seemed cheerful and talkative. You know, there is always one on the team who talks a lot and lifts the mood. However, as this AI is designed for collaborative ideation, it not only talked a lot but also suggested lots of ideas. I hope to get one soon. (p. 8)

> I felt the Co-bot's speech tone was a little cold, but in terms of the conversation, it seemed to understand exactly what I was saying. In the ideation process, I felt that

> Co-bot thinks a lot and led the conversation carefully to improve and develop my opinion. Overall, I think it's convenient. (p. 15)

In this regard, the study's lack of reliability and accuracy, considered a concern with the Wizard of Oz method, was somewhat overcome by establishing a consistent performance by the wizard (experimenter).

3.3.2 Finding 1: When brainstorming with AI agents, introverts are less concerned about their ideas judged

As a result of the Big Five personality type test conducted before the experiment, 10 out of 20 participants showed a relatively introverted personality. Moreover, these ten introverted participants showed different interactions from the ten extroverts during the brainstorming sessions. Interestingly, contrary to conventional human–human brainstorming, the introverted participants were less likely to show concern about what the coworker (i.e., the AI chatbots) thought about their ideas or how to persuade them. This tendency may cause challenges in collaboration with other humans, but we saw this tendency diluted in the AI agent collaboration. The following highlights some of the participants' comments:

> One of the things that always bothers me in brainstorming work is that it is difficult to give a negative comment or a critique of the other's opinion and my being aware of how they feel about my comments. (p. 14).

> Yes, I understand that it's important to talk to each other and criticize others' opinions to generate ideas in the brainstorming process. However, when coworking with people, I have a stronger desire to proceed smoothly by not offending the other person's mood as much as possible. […] But here, when I talk with the AI agent, I certainly don't have to worry about the opponent's feelings, so it was easier and more efficient. (p. 7)

> Obviously, if artificial intelligence pointed out my ideas to me, I would be less hurt and concerned than talking to people. AI agents are much better and more efficient collaborators than humans in this respect. (p. 9)

The participants agreed that active criticism is necessary to converge the different ideas in the brainstorming process. However, introverts deemed this particular process difficult in human collaboration, requiring a vast effort to avoid offending others and worrying about what others might feel, preferring to abstain from criticizing others' opinions instead.

Meanwhile, participants felt less pressure in the human–AI interactions and were more comfortable generating ideas because of the absence of the chatbot's physical form. Hence, we deemed the interactions involved to have less of an effect on the participants internally and externally. The introvert participants were less obliged to think about the AI chatbot's feelings or persuade it when exchanging ideas. In general, the participants had the opportunity to focus more on the purpose of the work itself, i.e., idea generation. For example:

> When working with strangers, you need the stage of rapport building in that you have to put your efforts on trying to get to know the person rather than on the purpose itself. But in conversations with AI, that was not necessary and that was such a relief. [...] I didn't have to kindly respond to the AI agent's greetings; I didn't have to respond thoroughly to every comment when I'm actually deep in my thought process [...]. (p. 17)

> When talking with people, or in this case collaborating with them, I had to engage a lot in persuading them to favor my opinion. And of course, I've been persuaded a lot as well. But when collaborating with the AI, I questioned myself, why do I always have to persuade others? Am I not the one making decisions? I don't have to talk deeply to change other people's minds [...]. (p. 20)

Throughout the preliminary study, we discovered the overall inclination of introverts not wanting to offend others and struggling to evaluate AI chatbot or own ideas during the AI brainstorming sessions. This trend extended to introverts interacting slightly differently depending on the personality type of their brainstorming partner, the AI chatbot. Introverts viewed extroverted bots as more empathetic and self-supporting than introverted bots and introverted bots as creating ideas through conversations with themselves. Such results stem from the psychological stability that occurs when the same personality types collaborate in a group. When evaluating individual performance during the brainstorming experiment, we found introverts rated themselves better in collaboration with introverted bots by 1:6 (3 ties). This finding is because introverts feel more psychologically secure in collaboration with people with similar personalities and conduct brainstorming more efficiently than collaborators who act as extroverts (Nass et al., 1995, 2000). Furthermore, in choosing the personality of the preferred AI agent, introverts preferred introverted bots by 4:6 and thought they would like to brainstorm together again. From this point of view, we confirmed the similarity theory in human–human collaboration in brainstorming collaboration between introverted people and AI chatbots.

3.3.3 Finding 2: Extroverts prefer humans to chatbot collaborators in brainstorming

Of the 20 participants, 10 showed a relatively extroverted personality type. Furthermore, the extroverts showed different attitudes and impressions after the brainstorming session with the AI chatbot compared to the introverts. However, when the extraverts self-evaluated the performance of the brainstorming session, we found no significant difference between the two personalities of chatbots, contrary to the results of the introverts. One participant wrote:

> The AI Chatbot and brainstorming experience was interesting. I worked with two types of chatbots, and there was no major problem in working with both types of

> chatbots, and I don't think I acted differently or did anything in particular. Both of the brainstorming topics were interesting, and I think the ideas came out well for a short time of 20 minutes. (p. 13)

Extroverts thought that between the two personas of the AI chatbot, there was no difference in the coworking environment, their preference, or the perceived efficiency. However, regardless of the personas, they expressed disappointment with the interaction experience. Extroverts prefer lots of conversation in brainstorming instead of inducing ideas; therefore, their challenge was interacting with the AI agent as frequently as they expected (compared to the interactions they typically have with other people). Furthermore, while they agreed that AI agents helped brainstorm, they thought that the AI chatbots lacked criticism, essential in generating ideas. Therefore, unlike the introverted participants, extroverts felt it was better to do it with a human rather than an AI chatbot. One participant said:

> I don't think brainstorming using chatbots is a bad idea. You can proceed whenever you want without the constraints of time, space, and partner, and that seems to be a great advantage. However, for me, it is still difficult to agree on whether the AI chatbot will replace a human partner. At a first glance, the experience of brainstorming with a chatbot was not much different from that with people. However, I think talking with real people is the most important process in brainstorming. (p. 11)

In addition, some of the participants expressed that they felt less distant at the first meeting than with a human, regardless of the chatbot's personality. However, they added that they also could not expect as much intimacy as in human interactions. In this sense, when designing AI chatbots, adding impractical expressions such as chatting and joking would help the users feel more intimate with the AI agent and the collaborative work. For instance:

> Compared to people, I definitely didn't feel distant even though I met it for the first time. But I think it's because I don't recognize the AI chatbot as a person, although I

> treat it like a human. When I talked with it, I acted like I was talking to a person, but at the same time, I didn't joke around or try to be a friend like in real conversations with people. (p. 1)

Extroverted participants said that verbal conversations with other humans were more suitable for generating ideas; in the conversation with chatbots, the initial thoughts or original ideas were refined and filtered when transformed to the text. This approach is because extroverts think that when they create ideas while having a conversation, they come up with more diverse, unrefined, and unusual ideas. On the other hand, extroverts think that if they go through with a typewriter, they limit the opportunity to come up with various ideas because you pass through the process of confirming your thoughts once. One participant said:

> Instead of saying something right after that comes to mind, my thoughts seem to be filtered out while I am typing. So I think it's much easier to talk directly with people face-to-face. (p. 2)

This belief reflects the general characteristic of the extroverts who want various and active interactions in the collaboration process. They felt the verbal conversation with the chatbot was uncomfortable and insufficient; they were also not satisfied with the non-verbal elements of the conversation. Unlike the introverts who felt differences between the two personas of the AI agent, the extroverts did not focus on differences. Instead, they focused on the number and variety of interactions with the AI agent.

3.3.4 Summary of findings from Study 1

In the experiment of the preliminary study, we were able to observe the following interactions for brainstorming using an AI chatbot. First, we observed that people with introverted personalities interact more freely and without a burden in brainstorming with the AI chatbots, unlike conventional brainstorming with humans. In their interaction with the AI

chatbot, introverts did not feel burdened by situations where the chatbot criticized their ideas or vice versa. Through the sessions, introverted participants thought that brainstorming with the AI chatbot was effective and especially preferred the introverted AI chatbot, which had a similar personality.

Second, we observed that the extroverted participants showed some differences in their experiences from the introverted people. Extroverts felt that interaction with the AI chatbot was not satisfying enough because they thought the most important aspect of brainstorming was interacting with other humans. In particular, some of the extroverted participants showed disappointment in conversations with the AI chatbot due to a lack of trust, intimacy, and bonding through jokes. For those extroverts, the overall interaction was more important than the practical interaction taking into account the other person's personality. As a result, they cared less about the personality differences of the AI chatbot than the introverts.

4. Study 2

4.1 Experimental design

Based on the findings from the first study, we designed the follow-up study to extend this area of investigation by a quantitative approach with a larger number of participants. The first study left clues that the brainstorming participants' extroverted personalities might influence the brainstorming experience with the AI agent. Therefore, the second study's goal is to observe the characteristics of introverts and extroverts in the human–AI brainstorming process more clearly. We also used the Wizard of Oz method in the second experiment, but we included a questionnaire for analyzing the quantitative results.

We designed the experiment where participants watched two brainstorming examples videos with the two AI personas and answered the questionnaire. The purpose and limitations

of this experiment are clear because the subjects who participated in the experiment answered the questions after watching the sample video, rather than answering the questionnaire after experiencing the AI chatbot and brainstorming process. Hence, through this following study, we tried to observe whether the results of the primary experiment were statistically significant and collect more users' perceptions through additional qualitative questions. We provide a detailed description of the experimental design below.

The videos showed a sample dialogue from a human–AI collaboration process, and they were created based on the actual conversation data from the preliminary experiment. We designed each dialogue to represent the different characteristics of the two AI personas, Di-bot and Co-bot, respectively. A total of two one-minute videos were created based on the two AI personas. Before distributing the questionnaire, we gave the following prompt to the participants:

> You are going to work with the AI chatbot next week for an ideation process. The following video is a sample conversation of the brainstorming process between a user and the AI chatbot. Please watch the video and answer the following questions about your expectation for next week's collaborative work with the AI chatbots. In this example, the brainstorming topic was "how to keep offline classes safe while maintaining a stable social distance after opening the university's space to students."

Then, we asked each participant to answer the questions after watching two consecutive videos that showed an example of the collaborative ideation process with the two AI personas. We randomly assigned the order of the videos based on the last digit of the timestamp when the participant started the experiment (Di-bot first for an odd number, and Co-bot first for an even number). Instead of actual participation in the collaborative ideation process, we gave the participants the prepared sample videos, asking for their expectations on

their supposedly arranged AI collaboration the following week. Participants answered the same question for both AI personas.

The questionnaire consisted of 24 personality test questions and 18 experimental questions on a five-point Likert scale (1: strongly disagree, 2: disagree, 3: *neither agree nor disagree*, 4: *agree*, 5: *d*), distributed after each collaboration video. The first question group consisted of a NEO-PI-R type personality test to determine whether the participants' personality type was extroverted or introverted based on the Big Five personality traits. The second section confirmed the character of the AI chatbot, which participants confirmed through the video, thereby accepting the bot as designed in the experiment. Finally, after collecting basic data from the experiment through the above two groups, we observed how participants perceived brainstorming using the AI chatbot in earnest at the end of the questionnaire.

Table 2. Questionnaire after the sample videos of the human–AI brainstorming process.

Part	**Subject**	**Questions**
BFM NEO-PI-R		**Q1.** ~ **Q24.** Big Five Personality - Extroverts & Introverts
Persona design of the chatbot	Verbosity	**Q25.** Do you think the AI chatbot will talk a lot?
	Empathy	**Q26.** Do you think the AI chatbot will easily empathize and agree with your proposal?
	Criticism	**Q27.** Do you think the AI chatbot will reject your offer or use a lot of antonyms in your utterances?
	Cautiousness/hesitancy	**Q28.** Do you think the AI chatbot will be slow to respond to your suggestions?
Expectation of brainstorming using the AI chatbot	Positive attitude	**Q29.** Do you think the AI chatbot will positively rate your proposal?
	Negative attitude	**Q30.** Are you concerned or dissatisfied with the AI chatbot evaluating your ideas?
	Positive mood	**Q31.** Do you think AI chatbots will create a positive mood in brainstorming collaborations?

Part	Subject	Questions
	Divergence	**Q32.** Do you think the AI chatbot will come up with different ideas in brainstorming?
	Likeability	**Q33.** If you were to have a direct collaboration with an AI chatbot, do you think you would like the personality of the AI chatbot?
	Intent to revisit	**Q34.** Would you like to brainstorm with the AI chatbot again?
	Reliability	**Q35.** If you were to have a direct collaboration with an AI chatbot, would you trust the AI chabot?
	Performance	**Q36.** If you brainstorm and collaborate with the AI chatbot, would the results be satisfactory?
	Bonding	**Q37.** If you brainstorm and collaborate with the AI chatbot, would you feel bonding and cohesion as a team member?
	Friendliness	**Q38.** If you brainstorm and collaborate with the AI chatbot, do you think you would easily become friends?
	Complementariness	**Q39.** If you brainstorm and collaborate with the AI chatbot, do you think the AI chatbot would become a team member that complements your weaknesses?
	Creativeness	**Q40.** If you brainstorm and collaborate with the AI chatbot, do you think it would be easy to develop new or creative solutions?
	Comparison with human brainstorming	**Q41.** Do you think brainstorming with an AI chatbot would be more effective for your personality than brainstorming with people?
		Q42. What's the reason?

4.2 Results

4.2.1 Validation of the persona design

Before analyzing the data, it would be wise to verify that the participants felt the personality of the AI chatbots as designed. At first, we checked whether they recognized the AI personas as we intended through the answers to the first five questions (Q25 to Q28). That is, after watching the sample conversations, if the participants saliently felt that each AI persona, Di-

bot, and Co-bot, represented distinct characteristics, they would have given different answers to the five questions. For example, the average score for Q1 would be significantly different if the participants recognized a different empathy level per persona from the videos. Next, we performed a paired t-test to check the difference in the five questions (Q25 to Q28) using a total of 44 answer sheets.

From the results, we found a significant difference in Q26, Q27, and Q28 with a significance level of 0.05 (Table 3). First, the participants thought that Di-bots were likely to produce more utterances than Co-bots, and they thought they were likely to agree and empathize with their proposals. These are two factors considered when designing a Di-bot, and they correspond to the amount of utterance and the degree of empathy. Second, the participants thought that Co-bots were more likely to reject their proposals or use more antonyms than Di-bots and were more likely to hesitate when answering. These are two factors to consider when designing Co-bots: antonym usage and dynamic delay. The results show that the precondition of the hypotheses was satisfied: through the videos, the participants perceived the two personas in the way the researchers had designed.

Table 3. Comparative results of the participants' recognition of the two AI personas.

Question number (subject)	**Mean difference (Di-bot–Co-bot)**	**Standard deviation**	t_d	**p-value**
Q25 (Verbosity)	0.432	1.531	1.871	0.068
Q26 (Empathy)	1.545	1.210	8.475	0.000*
Q27 (Criticism)	–1.523	1.210	–8.346	0.000*
Q28 (Cautiousness/ hesitancy)	–0.318	0.771	–2.738	0.009*

* significant at the significance level of 0.05

4.2.2 The difference between extrovert and introvert in AI brainstorming

As a result of the NEO-PI-R extraversion test, we classified 44 questionnaire participants into 22 extroverts and 22 introverts. To observe the difference between introverted and extroverted participants divided by 22 people, we first examined whether they thought the brainstorming process with an AI chatbot was more efficient than the process with humans. To this end, verifying the question (Q 41) by independent sample analysis confirmed an insignificant mean difference, as shown in Table 4. However, we confirmed that the distribution of the corresponding scores collected on the five-point Likert scale heavily weighted on the three-point scale. As a result of counting the number of subjects who thought brainstorming collaboration with AI chatbot was more efficient than collaboration with humans, and excluding subjects who scored three points, it was 6:13 (extroverted: introverted). Although it did not confirm statistically significant results, if 19 subjects, excluding neutral, had to brainstorm either AI or people, introverts preferred AI relatively more than extroverts.

Table 4. Differences in perspectives on the efficiency of AI chatbots.

Question	**Mean difference (Di-bot – Co-bot)**	**Standard deviation**	t_d	**p-value**
Q41(Comparison with human brainstorming)	−0.409	0.305	−1.342	0.187

Analogous to the preliminary results, introverts wanting liberation from coworkers' evaluations and burdensome or unnecessary interactions during collaborations, introverts in the following experiment also preferred AI chatbots to humans and deemed it more efficient for the following reasons:

> "I don't know yet, but I thought it would be efficient because I hope that unnecessary energy between people, such as negative words and actions, will not appear. I think it will be more helpful in that sense."
>
> "I am having a hard time conversing with a person, as I am a little concerned about what that person thinks of me, so I think using an AI chatbot will allow me to exchange opinions comfortably."
>
> "I think each party has its own strengths and weaknesses. If you work with an AI, you don't have to worry about your feelings, and it would be convenient to just talk about your ideas directly. But are they more creative than humans? The question still remains."

In addition, the introverted subjects preferred brainstorming collaboration with AI chatbots with similar personalities, i.e., introverted personalities, for the personality type displayed by the AI chatbot. This finding complies with the "similarity theory" from conventional collaboration, in which people prefer team members of similar personality types to theirs. As introverts perceived the collaboration with a similar personality type as more comfortable, it left the unfamiliarity of collaborating with an AI less of a hindrance. Introverts thought they would want to brainstorm again with introverted AI chatbots than with extroverted AI chatbots (Q34). They also thought that brainstorming with introverted chatbots would yield new and more creative results (Q36, Q40). We observed from Q35 that introverts perceived the reliability of introverted chatbots as partners higher than those extroverted chatbots. Additionally, from Q39, introverted participants deemed introverted AI chatbots better at compensating for their shortcomings than extroverted chatbots. Table 5 summarizes the findings.

Table 5. The difference in personality traits of an introvert.

Question	Mean difference (Di-bot – Co-bot)	Standard deviation	t_d	p-value
Q29 (Positive Attitude)	1.227	1.236	6.585	0.000*
Q30 (Negative Attitude)	−0.068	1.404	−0.322	0.749
Q31 (Positive mood)	0.295	1.133	1.730	0.091
Q32 (Divergence)	−0.841	1.478	−3.775	0.000*
Q33 (Likeability)	0.045	1.539	0.196	0.846
Q34 (Intent to revisit)	−0.500	1.355	−2.447	0.019*
Q35 (Reliability)	−0.636	1.416	−2.982	0.005*
Q36 (Performance)	−0.568	1.189	−3.170	0.003*
Q37 (Bonding)	0.341	1.509	1.499	0.141
Q38 (Friendliness)	0.159	1.380	0.765	0.449
Q39 (Complementariness)	−0.886	1.146	−5.132	0.000*
Q40 (Creativeness)	−0.523	1.285	−2.699	0.010*

*Significant at the significance level of 0.05.

On the other hand, in the case of extroverted participants, they preferred humans over AI chatbots because of the technical limitations of AI. In addition, they indicated that they preferred close interactions with other people during the brainstorming process.

> "AI has a learned aspect, so it sees a specific case and applies it to the next. It would be a good choice if only I was trying to come up with an idea suitable for a certain project, but I like and value creative ideas and friendly conversations with people. I will use AI for my projects, but I don't think it fits my personality very well."
>
> "Because it is a machine, not a human, there seems to be a prejudice that there are limits to ideas. It may be different depending on what kind of person you are, but I wonder if AI will only answer within a framed framework. However, AI seems to have a pretty positive effect in terms of giving unconditional empathy."

Furthermore, we observed no significant cognitive differences between extroverted AI and introverted AI in the case of extroverts. This finding results from the previous experiment's conclusion that extroverted people do not care much about the personality type of group members. We believe that extroverted characteristics value interaction and intimacy with the other person more than the other person's personality.

5. Discussion

5.1 Summary of findings

We observed the characteristics of introverts and extroverts during the brainstorming process using the AI chatbot through the previous two experiments. Previous studies have shown that introverts are not good at coming up with ideas or are reluctant to interact because they are afraid of others judging their ideas. However, introverts in brainstorming with the AI chatbot showed no reluctance to interact with the AI chatbot, in contrast to the previously validated results. Furthermore, they were more psychologically stable than when interacting with humans. Moreover, they thought that more active interaction and communication was possible based on such psychological stability. Introverts did not feel repulsed by the situation when the AI chatbot tried to criticize or revise their ideas. Instead, they found that they were able to interact with the AI chatbot's ideas relatively easily. Based on these interactions, introverts in the brainstorming process perceived themselves more efficient.

Conversely, extroverts had a negative view of AI chatbots and thought brainstorming with actual people was more effective. Extroverts believed that the interaction emerging from the brainstorming process with people was the most critical aspect of the brainstorming process. With the AI chatbot, they found such interaction lacking. For this reason, in the case of extroverts, they did not show much interest in the specific personality type of the AI chatbot; they focused on the interaction with the AI chatbot itself.

5.2 Use of AI chatbot to overcome the existing limitations of brainstorming

Existing research literature points out various limitations of brainstorming according to team members' personality types and combinations. Other studies looked at ways to solve these problems and maximize idea thinking, including anonymous brainstorming, individual brainstorming, and electronic brainstorming. From this point of view, this study shed light on the possibility of utilizing AI chatbots to overcome the limitations of conventional human–human brainstorming, especially among introverts.

In this study, participants showed they thought they had the following advantages in the brainstorming process through chatbots. First, it was easy to check the previous conversation history. Second, it was easy to grasp the entire conversation flow regardless of the speed of the conversation. Third, it was easy to organize their thoughts and continue the conversation before chatting. Furthermore, some introverts reacted differently depending on the time the AI agent took to respond. In the first experiment, the participants answered they were comfortable exchanging negative opinions with the AI agents; they also felt that when the AI agent took more time to respond, it was thinking more deeply about their ideas. Thus, although the participants were aware that they were talking with an AI agent, they felt the conversations were more human-like the more the AI agent responded with longer delays. As a result, they became more accepting toward the collaborative process with the AI agent and formed a more efficient mindset for the idea-generating process. One participant stated:

> It felt like the AI agent was 'thinking' when it responded with delays. On the other hand, when it responded quickly, it was as if it already knew what to say. I grew to trust the agent more when it responded with delays. I wouldn't trust it if it responds too quickly when I suggest an idea. (p. 12.

In other words, the AI chatbot can adjust the response rate to positively tune the other person's perception and provide a user-friendly and convenient interface throughout the

brainstorming process. In addition, it suggests the potential to greatly reduce the limitations in conventional brainstorming sessions, especially for the introverts shown to have more vulnerability in this area. Given these points, our study sheds light on the possibility that the AI chatbot's brainstorming process could be a way to overcome the existing limitations.

5.3 Need for segmented research depending on the purpose of AI collaboration

Previous literature emphasized the need not to expose the identity or the persona of an AI agent and deemed it an important consideration when designing the agent. If they know the AI agent's identity, the interacting users might not wholeheartedly treat it exactly as they treat other humans. Still, they often expect a similar level of interaction and for the AI to be interactively similar. Thus, researchers found that the more an AI agent expresses empathy and shows how it relates to the user, the more the user feels it is human-like and more interactively efficient during the study of an AI agent's personas (personality and behavioral types) (Hanna et al., 2015). Such a result derives from the user's positive mindset toward the AI agent due to the empathy and relationship it presents, which deems it more human-like.

Nonetheless, this study focused on an AI agent with a particular purpose, the brainstorming process, and found a significant difference from other existing AI agents. Participants deemed Di-bot less efficient in the collaborative ideation process, even though it had a persona that emotionally empathized and related more to the users. However, they asserted that it was not because they considered empathy as less necessary or not preferable, but because it was simply not helpful or even hindered purpose-driven conversations like ideation. On the contrary, they found logical criticisms and cognitive identification more helpful than emotional identification in understanding their opinions and refining their ideas to perfection. For these reasons, the participants regarded Co-bot as more efficient in ideation

processes, which led the conversation more critically than did Di-bot, which was more accepting and expressed positivity to their ideas.

The results establish a need for clarifying the AI agent's purpose as a requisite to designing the personality traits of the AI agent. Further, we found that not all AI agents have to be conforming and sympathetic to the user, especially in ideation processes in which creative collaboration is vital. However, given that some participants responded positively to the sympathetic attitude of the AI agent, determining which characteristics are best suited to such a purpose needs further research. Therefore, we deem necessary a segmented analysis of each stage of the ideation process and its relation to the sympathetic tendency of the AI agent.

5.4 Limitations and future research direction

This study incorporated two methodologies to create and observe the brainstorming process between the AI agent and user. Using the Wizard of Oz method in our preliminary experiment, the experimenter acted as an AI agent to lead the participants to think it was an AI–human collaborative process. The Wizard of Oz methodology is an effective means often incorporated in human–computer interaction, especially when working with AI, which is not yet a fully cultivated area of research (Zhou et al., 2019). Although results derived from this methodology are less likely to be distorted, as the participants regard their interactions as human–AI, there still exist limitations, as in reality, the actual artificial intelligence agent does not exist. Furthermore, the participant's recognition of the technology of the perceived AI agent could be much more advanced than it is currently.

In addition, due to the intricacy of actual collaborative processes and the recruitment of a large number of participants for quantitative analysis, the participants watched a one-minute-long video on an AI–human collaboration process instead of performing one in our subsequent experiment. To avoid the possible misrepresentation of our results, the

questionnaires in our next investigation focused on the environmental and situational aspects of the collaboration process rather than detailed insights into the ideation process. Nonetheless, we acknowledge the limitations regarding the data obtained from the participants who were not directly involved in the human–AI collaboration process.

We will construct detailed collaboration situations with AI agents to counteract the limitations mentioned above for future work. Designing an AI agent capable of an actual collaboration process with users would require a profound amount of time, but developing a specific model suited for particular conversations for the brainstorming process is immediately feasible by employing different scenarios. Furthermore, this study focused on an ideation process that we collectively generalized as one. However, works involving generating ideas and working collaboratively entail numerous factors such as the type and number of collaborators and the collaboration topic; therefore, segmented analysis and research on each factor are essential for further study.

6. Conclusion

With the advancement of AI technology, AI chatbots are now prevalent and used in various corners of daily life. The trend has expanded to encompass work processes previously done between humans to those between humans and computers. This influence extends to creative fields, once regarded as the scope of humans only. Consequently, this highlights the demand for research on collaborative brainstorming processes between humans and AI agents.

In this study, we divided the comparisons into introverts and extroverts. We tried to determine what kind of interactions people with each personality showed during brainstorming with AI chatbots and how they felt about the experience. We designed two AI agents, each with a different persona, Di-bot with an extrovert persona and Co-bot with an introvert persona, to find an effective means to the brainstorming process. Using the created

AI persona, we experimented and observed the brainstorming process between humans and AI chatbots, and as a result, we were able to attain the following findings.

In conventional brainstorming between humans, introverts tend to avoid situations where others evaluate their ideas; this tendency prevents them from active participation. On the other hand, in the case of brainstorming using the AI chatbot, the introverts showed psychological stability and greater enthusiasm in the brainstorming process. In the case of extroverts, the most important feature was the interaction with the other person in the brainstorming process with humans; however, they could not experience the same in the brainstorming with the AI chatbot. Regardless of the personality of AI chatbots, the extroverts claimed that interactions with AI chatbots were less satisfactory than those with humans. As a result, we found that introverts preferred brainstorming with AI chatbots, while extroverts preferred brainstorming with humans.

These findings show that the brainstorming process can expand into human–computer interactions in the human-to-human process and contribute as follows. First, we evaluated how the brainstorming process differs in a human–AI brainstorming setting based on participants' extraversion and introversion personality types. Second, we suggested that introverts felt more efficient in the brainstorming process using AI chatbots than with humans. Finally, we identified considerations distinct from the findings from the literature review on general human–AI interactions. For example, in previous studies on AI agents and personas, empathy was the main requirement for a user-friendly experience and was requisite when planning a persona. However, for specific purposes such as brainstorming processes, as discussed in this study, a critical attitude of the AI agent is shown to be more important than an empathetic attitude, which turned out to interfere rather than help. Hence, our study proposes that identifying different focus points depending on the particular purpose is vital in designing an AI agent.

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