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The pursuit of happiness: the power and influence of AI teammate emotion in human-AI teamwork

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ABSTRACT

As the world evolves, human-AI teams (HAT) have become increasingly more capable in their ability to complete task objectives. Due to this rising importance, it has become essential to understand the interpersonal dynamism between humans and AI to further optimise their performance potential. Given the demonstrated utility of emotional communication within human-human team structures, this research investigates the nature of AI-sourced positive emotions on human teammates. Through 47 interviews, our findings show that for these AI teammates to be accepted, human teammates have preferences on understanding the emotional utility prior to its presentation, as well as which emotions are situationally acceptable. Also, findings show that integrating emotions within AI teammates has a positive influence on human perceptions and behaviour in a task. In further detail, emotions act as status updates that allow human teammates to not only better understand their teammates' mental states but also understand how their AI teammates perceive the situation around them. Together, this gives insight into how AI emotional expressions influence the perception of social support on the wider Human-AI team. Mainly how emotions can be used to increase acceptance of AI teammates and improve the overall experience human teammates have within the task.

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1. Introduction

With artificial intelligence (AI) becoming progressively more versatile in its applicability, human interaction with these AI technologies has correspondingly increased in complexity and capability, leading to the recent research focus on partnered collaborations between humans and AIs in teams (HAT) (O'Neill et al. 2022). Often, these human-AI collaborations are facilitated by both formal and informal communication (Wognum and Faber 2002), and research from a variety of domains, including psychology and computer science, has worked to investigate these methods of communication to increase collaboration (Andrejczuk et al. 2018). Emotion, which can be defined within this study as categorical discrete mental states (eg. joy, serenity, ecstasy, sadness, trust, anticipation, etc.), act as important modifiers to communication between teammates as it becomes an indicator of how events are being internally processed (Lange, Heerdink, and Van Kleef 2022; Plutchik 1960). Humans, as biological beings, have experienced these emotions as physiological responses to situational events (Plutchik 1960). With time and diverse experiences, humans gain proficiency in being able to recognise and, in many cases, empathise with other individuals as they express their responses to the world (Salovey and Mayer 1990). Awareness of personal emotions is only half of the whole picture that is emotional intelligence, as humans then regulate their emotional awareness to informally communicate to others how they perceive situational events. In communicating these emotions, humans tend to enact both nonverbal and verbal cues through a number of means, like facial or text-based expressions (Salovey and Mayer 1990). Teammates can utilise this information to better inform their decision-making on the amount of social support needed to ensure well-being and task success (Luca and Tarricone 2001; Rosenfeld and Richman 1997). Research domains such as human-computer interaction (HCI) or affective computing, take advantage of the innate emotional intelligence of humans and have demonstrated the fundamental role of emotional expression in facilitating communication in technology-mediated environments for over thirty years (Derks, Fischer, and Bos 2008; Picard 2000). In these

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instances, a focus has been placed on using text-based communication to accentuate emotion in artificial agents, as it places a lesser burden on interpreting non-verbal behaviour (Fan et al. 2017; Picard 2003). In leveraging the power of emotional implementation in communication, researchers and practitioners have created more engaging and enjoyable interactions between humans and computers (Inkster, Sarda, and Subramanian 2018; Ochs et al. 2008; Pelau, Dabija, and Ene 2021; Wang 2017). Considering this, it becomes worthwhile to account for the social influence of an AI displaying emotions on their human teammate's behaviour and the conditions necessary to warrant social influence in this way. By accounting for the role of emotion in this setting, AI would not only be able to improve the relationship between humans and AI but also beneficially build upon interaction capabilities to leverage AI as a true collaborative *teammate*. This extends beyond the perception of humans utilising AI as tools and instead focuses on the perception and behaviour in which humans and AI work interdependently with each other without the need for continual supervision, a core benefit of human-AI teams (McNeese et al. 2018).

Rooted in this foundation of improving work-based enjoyment, research on the emotional benefits to teams has indicated that positive moods benefit team outcomes, as humans that communicate through emotional expression can build greater levels of trust that also support positive performance outcomes (Lange, Heerdink, and Van Kleef 2022; Tong et al. 2021). Furthermore, emotional exchanges between two human members can also facilitate the growth of relationships as the perception of care and concern from others makes individuals more invested to trust them Rimé (2007). This form of emotional support, a sub-component of wider social support, is a preconceived expectation humans have from one another, especially when entering task-oriented assignments (DeFreese and Smith 2013). Similarly, emotions have the same potential to improve trust and cohesion as a means to further enhance the relationship between humans and AI. When considering AI and its utility in working with humans, integrating emotions as a communication medium with AI presents a promising approach for humans to interpret the clouded and ambiguous nature of an AI's decision-making process, as this nature often leads humans to distrust the AI with which they work (Riedl 2019). Within the trend of AI development that prioritises human-centred design, there is a focus on creating AI systems that can simulate emotions, either through behavioural expressions embodied in physical forms such as robots or textual communication when used as chatbots. In these instances, a physical representation allows AI to utilise gestures, facial features, and posture to display emotion (Fan et al. 2017). However, as seen in instances with virtual AI, and even more specifically AI teammates, it has been expected that AI has the natural language capabilities to push and pull task-related information between teammates as needed (Demir, McNeese, and Cooke 2017; McNeese et al. 2018). This has predominantly been implemented through textual means, where HAT research has additionally revealed that humans desire an AI teammate that is gentle and 'warm' to combat existing preconceptions of it being socially incapable (Harris-Watson et al. 2023). Additionally, when these AI agents strategically leverage their communication displays to be emotionally rich in content, specific emotions like joy, surprise, and disappointment can be invoked from the humans who perceive them West, Patera, and Carsten (2009) and Shank et al. (2019). In combating this negative preconception, implementing positive emotions to be simulated by an AI teammate promotes a trusting relationship between humans and AI as it gives a perception of the AI providing emotional support, a core component of social support (Glikson and Woolley 2020; Wang et al. 2023). This trust proliferates into related factors of successful teamwork, such as increased cohesion, efficiency, and individual well-being by reducing stress (Fan et al. 2017; Lyons et al. 2019). Given this potential for enhanced teammate relationships, emotions can evidently play an important role within human-AI teams as they have demonstrated in team situations and human-computer interactions. With this consideration that HATs are a novel team structure that simultaneously leverages the unique qualities of humans and AI for a shared team goal (McNeese et al. 2018), research must advance prior work in human-computer interaction (HCI), human-human teamwork, and computer-supported cooperative work (CSCW) to understand the role of AI's emotions in these teams.

However, despite the existing research on emotions from the perspectives of team psychology and computer science, fundamental questions arise when examining the integration of emotions in teams comprising both humans and AI collaborating seamlessly. In pursuit of a deeper understanding of artificially displayed emotions, this study first investigates the presentation and acceptance of AI teammates' emotions in human-AI teams. Secondly, because it is not enough to just understand the influence of emotion alone, we explore how humans anticipate AI-sourced emotions to benefit the team's ability to be successful. As well thirdly, how emotionally expressive AI teammates socially support human teammates. Therefore, this study focuses on positive emotions as they have been shown to promote 'cohesion, cooperation, coordination, conflict, and satisfaction' (West, Patera, and Carsten 2009) within human-human teams. Indeed, in the current human-human team literature on interactions with emotions, researchers regularly manipulate positive emotions to investigate how a *good* teammate not only boosts individual human performance but also improves task understanding for all team members (Berg and Karlsen 2014; Wolff, Pescosolido, and Druskat 2002). Moreover, research has shown some, albeit limited, benefits of positive emotion expressed by AI systems, robots, and personal assistants interacting with humans outside of a teaming scenario (Kiesler et al. 2008; Vögel et al. 2018; Złotowski et al. 2015). Thus, our exploration of positive emotions in AI teammates is not only warranted from both teaming and technological viewpoints but also stands to enhance our comprehension of how AI displaying emotions ultimately benefits human teammates.

In exploring emotions in human-AI teams, we interviewed 47 participants regarding their perceptions and preferences of AI emotional expression after participating in a collaborative video game that utilises human-AI teamwork. With this work, we focus on the following research questions:

(1) *Under which circumstances would humans accept emotionally expressive AI teammates?*
(2) *How do human teammates anticipate textually sourced AI emotions to benefit team outcomes?*
(3) *How do emotionally expressive AI teammates provide social support to HATs?*

In answering the above research questions, this study provides three specific contributions to the Journal of Behavior & Information Technology through the exploration of human-centred emotional AI teammates. First, this work creates an understanding of how humans perceive emotion when presented textually by an AI teammate, offering insight into the preferred amount of social support humans want from these AI teammates and therefore how the overall HAT should function. This is a critical component to ensuring that the HAT, a novel extension of the broader field of HCI, is designed to fit the wants and needs of humans with whom they collaborate, ensuring they are better accepted as teammates. Second, our findings explore how humans anticipate the emotions expressed by AI teammates, which can benefit team outcomes. These insights surrounding team outcomes provide a critical contribution to existing team research and future teams, as they build upon our existing understanding of how emotions can benefit teams. Finally, our findings explore how AI teammates use targeted social interaction to enhance how human teammates experience the task. Taken in sum, this work strives to ensure AI teammates become a social and collaborative technology that is designed to benefit human-AI teams, their interactions, and their outcomes.

2. Background

In this section, we foreground this work by discussing the current literature on the role that emotions play in human-human teams and the current understanding of human-AI teams. We first discuss foundational emotional theories and transition to their relevancy in general teaming practices as a communicative medium. Then we scope down from the wider teamwork literature to explore how emotions have been used so far in the development of human-centred AI. In doing so, this literature review highlights the specific research gaps that this study aims to address.

2.1. Perceptions and value of emotional expression

Human emotions remain an enduring topic of research to enhance understanding of interpersonal dynamics in various types of relationships, including as indicators of mental states. Researchers, though, use a wide variety of methods for classifying and explaining human emotions, such as Plutchik's Wheel of emotions (Plutchik 1960), Eckman's emotional theory (Sabini and Silver 2005), and Russell's circumplex model of affect (Russell 1980) are a testament to this fact. Robert Plutchik's theory of emotions covers a 3-D representation of eight core emotions (joy, trust, fear, surprise, sadness, disgust, anger, and anticipation) and discusses their relationships to each other, as well as the concept of emotional intensity, which form additional, more complex variants compared to the core eight (Plutchik 1960). In contrast, James Russell's circumplex model of affect theorises the categorical placement of all affective states into two neurophysical axes: pleasure-displeasure and arousal via activation vs. deactivation (Russell 1980). Despite their differences, the central aim of these theories is that emotions should be thought of from a neuro-behavioural perspective as descriptors of mental states given their physical neural pathways (Posner, Russell, and Peterson 2005). As such, emotions are representative of individual levels of arousal and contentedness and describe their attentiveness to the present situation. Regardless of emotional theory, the foundational work developed in the literature represents emotions as a descriptor of an individual's emotional state via positive and negative emotions.

2.1.1. Interpersonal value of emotional communication within teams

These descriptors extend beyond the individual mindset, though, and are prevalent in interpersonal relations, as these feelings uniquely characterise and define relationships (Rimé 2007). In considering the dynamics of teamwork, we recognise that these expressions and their differences play a prominent role in how effectively people perceive the emotions displayed by others (Methot, Melwani, and Rothman 2017). Despite the focus on more intimate relationships, the interplay between emotions and relationships is not limited to friendships or romantic relationships, and much literature focuses on the role of emotions within professional team relationships, an important focus for this study (Methot, Melwani, and Rothman 2017). Traditionally viewed as a human biological feature by psychologists, emotions have been shown to be highly effective for enhancing social relationships (Fischer and Manstead 2008; Kramer, Guillory, and Hancock 2014; Tong et al. 2021). In a goal-oriented task, emotions are a feedback instrument where multiple people gain a higher understanding of the situation and its impact on people (Lord and Kanfer 2002). When people interpret their teammates' emotions and intents through explicit and implicit cues, can then be influenced to act by those perceptions (Lange, Heerdink, and Van Kleef 2022). For instance, a person is far more likely to accept help from a teammate expressing concern as opposed to one expressing anger and frustration. Despite this, any emotions expressed become an indicator for teammates to provide social support to better regulate its influence on the team's outcome, such as being neglectful from overly joyful/sad to make performance mistakes (Tamminen and Gaudreau 2014). Social support is a multidimensional construct in which humans have expectations of receiving affective (emotional/esteem) and task-related (informational/tangible) support that directly improves 'process gains' of teamwork (Hüffmeier and Hertel 2011; Rosenfeld and Richman 1997). Research shows that the relationships between teammates, including trust and affinity, are dependent on these perceptions of each other's emotions (Rimé 2007).

When considering emotional perceptions, we must also discuss the types of emotions, particularly those deemed negative and positive, and how their differences affect social relationships and teamwork. Negative emotional states include but are not limited to, 'sadness', 'anger', 'rage', 'boredom', and 'fear' (Mohsin and Beltiukov 2019). These emotions have a negative connotation, especially in professional settings, because they are considered 'counterproductive' to the goals of efficient work (Fida et al. 2015; Fox, Spector, and Miles 2001) as well as contribute to feelings of distrust (Jones and George 1998), incite more conflict (Spector, Fox, and Domagalski 2006), and decrease overall performance (Cole, Walter, and Bruch 2008; Farh, Seo, and Tesluk 2012; Johnson et al. 2020). Researchers often point out that counterproductive work behaviour incited by negative emotions alienates the individual from their coworkers, straining relationships and hindering collaboration (Fox, Spector, and Miles 2001; Jones and George 1998). Additionally, another empirical study found that when participants were introduced to negative emotions prior to performing a task, they were 66 percent more likely to make a mistake than the control group (Johnson et al. 2020). Despite this, few studies within the domain of human-human teamwork mention the usefulness of negative emotions. Moreover, those that consider the utility of negative emotions focus on how lower intensities of negative emotions (like apprehension or dislike) are needed to evaluate ideas and teamwork for effective outcomes and overall team improvement (Stephens and Carmeli 2016) or how they highlight friction in relationships for which conflict management techniques must be implemented (Troth et al. 2012). Despite these studies, there remain questions concerning the disparate perceptions regarding the impact of negative emotions in the workplace.

On the other hand, positive emotions are seen as highly desired emotions within the workplace. Positive affective states include 'joy, interest, contentment, and love' among others (Fredrickson 1998). When humans express these emotions, they often develop more satisfying relationships (Berg and Karlsen 2014; Tse and Dasborough 2008) and perform better in their given task (Hazelton 2014). Maintaining and strengthening social relationships via positivity is critical to good teamwork, as individuals are more likely to work together because positive emotions help resolve interpersonal conflicts (Bar-Tal, Halperin, and De Rivera 2007; Lindner 2006). Positive emotions also allow humans to showcase the range of their authentic communication to express the value of the relationship to an individual (Tse and Dasborough 2008). As such, positive emotions can heighten overall team cohesion and encourage fruitful interactions that improve performance (West, Patera, and Carsten 2009; Zurcher 1982). Furthermore, positive emotions help teams perform better in organisational environments while improving their resilience towards negative events (Meneghel, Salanova, and Martínez 2016). Additionally, along with performance and resiliency, West, Patera, and Carsten found that positive emotions bring a sense of optimism that supports overall team outcomes (West, Patera, and Carsten 2009). Given the bountiful benefits of positive emotions to teamwork dynamics, it is imperative to explore the extent to which they also influence human-AI teams and whether an AI teammate is capable of augmenting similar effects.

2.2. Human-AI teams and their potential benefit from emotion

While human-human team compositions have been the longstanding benchmark for interpersonal collaboration and innovative problem-solving, human-AI teams (HAT) represent a new framework for exploring the usefulness of AI as an additional team member. HATs are teams that have at least one human and one AI with interdependent roles and shared team goals (McNeese et al. 2018). The idea of humans working with technology in a team setting is not a new concept in wider fields like Human-Computer Interaction and Human-Automation Interaction (O'Neill et al. 2022), but the main facet that sets HATs apart is the perception of AI not as tools but as collaborative teammates (Demir et al. 2015; McNeese et al. 2018; Zhang et al. 2021). In the aforementioned fields, computers and automation differ from AI in that those machines are programmed to accomplish a specific task and are considered brittle and inflexible towards new stimuli (De Visser, Pak, and Shaw 2018; Endsley 2017). In contrast, AI's autonomy is designed to handle dynamic environments, even if they are not trained for new stimuli (Benbya, Davenport, and Pachidi 2020). AI's adaptability helps humans to consider them as independent teammates worthy of trust who can handle their tasks without much oversight (O'Neill et al. 2022), allowing humans to devote less cognitive resources to AI-adept tasks and focus their attention toward tasks and roles suited to humans (McNeese et al. 2018). However, this trust is not given outright because for realistic teammate dynamics to exist between humans and AI, there must be a platform of bi-directional communication where humans and AI are able to push and pull information to raise their mutual understanding of each other and the system around them Shively et al. (2017), Schaefer et al. (2017), Schelble et al. (2020), Marathe et al. (2018) and Demir et al. (2015). Within these circumstances, communication transforms to best fit the type of AI that is needed for the task. For instance, within simulations where AI teammates are disembodied software performing distinct roles like mapping routes (Demir et al. 2015; Schelble et al. 2020), explicit verbal or written communication augmented via natural language processing is needed to improve the exchange between the two (Chen and Barnes 2014; Schelble et al. 2022). Whereas, with embodied AI in the form of physical robots, or virtual avatars, communication can utilise the added feature of transparent, visual manipulations on its interface to support bi-directional comprehension (Chen and Barnes 2014; Lemaignan et al. 2017; Mercado et al. 2016; Schaefer et al. 2017). While these considerations of the AI teammate's representation are relevant, recent research has indicated that the 'warmth and competence' of an AI teammate is considered of higher utility to the acceptance of an AI teammate in human-AI teams (Harris-Watson et al. 2023). Given the iterative nature of AI design, developers will likely keep advancing on this path in implementing new and diverse methods to support the creation of human-centred AI teammates (Benbya, Davenport, and Pachidi 2020). Therefore, it continues to be imperative that researchers explore the essential core of HAT characteristics to better understand the nuanced relationship between humans and AI.

Researchers must understand the critical characteristics of HATs to improve the effectiveness of this team dynamic. These characteristics include but are not limited to, shared mental models, situation awareness, and communication (Mallick et al. 2022; McNeese et al. 2018; O'Neill et al. 2022; Schelble et al. 2022; Zhang et al. 2021). In HATs, shared mental models are the foundational knowledge all teammates need to understand each other's capabilities and current mindsets (Schelble et al. 2022). With AI teammates, particularly those without an embodied representation, creating a shared mental model can be imprecise at times due to the lack of human interaction experience or the inability to understand AI decision-making (Adadi and Berrada 2018). However, with the integration of emotionally expressive AI, a refined mental model can be developed such that human teammates can comprehend the mental status of an AI teammate in relation to the task. As discussed in a design framework regarding humans teamed with text-based negotiation support systems, emotional status, and coping style should be acknowledged as supplemental information to build accurate mental models between humans and AI teammates (Van De Kieft et al. 2011). In doing so, these mental models provide clarity as to how the AI teammate can interpret and react to the environment (Mallick et al. 2022). Otherwise known as situational awareness, effective HATs become contingent on AI teammates' ability to demonstrate their adaptability to dynamic environments so that human teammates see their AI teammates as reliable and trustworthy (Demir, McNeese, and Cooke 2017; Schaefer et al. 2017). Emotions could become one such method to demonstrate an AI teammate's ability to perceive and comprehend the changes in a situation, as developers have already demonstrated this design and posited its utility in various human-AI interactions where the AI is both text-based as well as embodied (Crowder and Friess 2012; Harris-Watson et al. 2023; Katayama et al. 2019; Schaefer et al. 2017). Similarly, the emotional expression of an AI teammate can act as a variant of communicative dialogue that improves team function. As such, the ability to effectively communicate between humans and AI teammates must be continuously investigated since it varies based on the situation, task, and representation of the AI. Specifically, in the realm of explainable artificial intelligence (XAI), emotional expression by AI can improve the interpretability of the embodied AI's beliefs and goals (Neerincx et al. 2018). Written from a HAT perspective, authors describe a theoretical framework of communication such that emotional expression can act as explanations on behalf of the embodied AI teammate's intents and actions (Neerincx et al. 2018). Other studies that investigate explainable AI teammates within HATs demonstrate that effective communication can lead to trust between humans and virtual text-based AI teammates (De Visser, Pak, and Shaw 2018; Schelble et al. 2022). With emotions relevant to the fundamental characteristics of HATs, trends have emerged on the potential impact emotionally expressive AI has within HATs; however, the field still needs greater empirical data to support theoretical frameworks and findings from adjacent fields.

3. Methods

This study employs a thematic analysis of interview data to answer our research questions about the role of positive emotional expression in human-AI teams. We chose this approach to focus on (1) the conditions necessary to accept emotionally expressive AI teammates (RQ1); (2) the perceived benefits of textually sourced AI emotions on team outcomes; and (3) the ways in which emotionally expressive AI provide social support to HATs.

3.1. Participants

Forty-seven participants were recruited from a participant pool at a large university in the United States with an average age of 18.89 (SD_{age} = 0.82). This subject pool is open to all registered students of the university enrolled in the introductory psychology course, which is considered a degree requirement for a distributed number of majors. All participants were native English speakers with previous experience working in teams and consisted of 29 females (with the rest self-identifying as male). Participants received course credit as an incentive for their participation in the study.

3.2. Procedure

At the start of the session, participants were first informed of the nature of the three-hour study, explaining that it involves pre-task surveys, four rounds of game-play, and concludes with a post-task interview. Once they provided consent, the proctor introduced and explained *Netrek*, the aerial combat game they would play. This included an overview of its design, objectives, and all available actions players can make within this environment. Additionally, during this time, the researcher stressed the teammate dynamic among the individual human and their multiple AI teammates, which were designed to express emotions and other communication in the chat. The human participant was told to be aware of the chat at all times and to reply to each message sent by the AI, 'player 1', with a 'message seen '. Because game data was video recorded, researchers could note if the participant read the emotional manipulation. After an initial training round, the participants completed three rounds of the task with accompanying surveys. The pre-task surveys captured demographic information, while the in-task surveys captured the perceived performance of the AI teammate. The in-task surveys, however, exist outside of this paper's scope and are therefore omitted to preserve the focus of this contribution. Once the final round and accompanying surveys were completed, a single post-task interview was conducted with an average duration of 60 minutes. This interview gave participants the opportunity to discuss the AI teammate's emotional expression and how they perceived the influence of the AI teammate's emotional expressions on the teamwork of the entire team. Participants were additionally encouraged to discuss how such perceptions of an AI teammate's emotional communication would be helpful for generic human-AI teams beyond the constraints of Netrek. Once the interview concluded, the researcher informed the participant of the use of deception as 'player 1' was a human player controlled using a Wizard of Oz technique (Maulsby et al. 1993).

3.3. Interview context

As this paper focuses on the particular social influence of an emotionally expressive AI teammate, qualitative interviews provide the descriptive information necessary to explain how and why this is a benefit towards human-AI teams (Merriam and Tisdell 2015). In this way, qualitative data provides the flexibility needed to inquire about the perceived benefits of emotionally expressive AI in a post hoc manner. In these exploratory discoveries, the field benefits from obtaining rich, descriptive information regarding complex and novel concepts like artificial emotions from an AI teammate. Moreover, with hour-long interviews, participants gain the freedom and time to self-reflect and provide engaging responses that they may not have considered previously, or have been able to relay through other data collection means. In relation to the overall goals of the study, their responses provided a comprehensive overview of how a generic AI teammate's emotions should be developed by actively thinking through their likes and dislikes of what they experienced in-game. In doing so, interviewers were able to take this time to probe *why* they had those preferences to better understand the conditions necessary to fruitfully implement AI emotion **RQ1**. Additionally, participants reflected on the emotional text that was displayed by an AI and were able to comment on anticipated benefits to the team **RQ2** as well as how it reinforces the perception of social support to HATs **RQ3**. Thus, to contextualise the qualitative data, we must provide a thorough explanation of the task environment, teammate relationships, and manipulation of the AI teammate's emotional expression. Together, these explanations give a contextual understanding of the varying social influence and preferences humans have for their emotionally expressive AI teammates and provide insight into its external validity.

3.3.1. Task environment: netrek

Netrek, an open-source battle simulation game, was chosen to replicate a dynamically changing HAT environment that stresses active collaboration needed by teammates to mutually support each other's goals. Inspired by the fictional 'Star Trek' universe (Di Pietrantonio and Mendonca 2020), The game tasks humans and AI agents to work together within a single team to destroy enemy ships, capture enemy planets, and protect their teammates from harm to earn the most points. Teams are composed of six to eight players with one of those players being the participant, another being the human acting as an AI teammate using a Wizard of Oz technique, and the remainder as actual AI teammates. The opposing team is composed only of AI teammates with the same design and priorities as the participant's team (Huber and Hadley 1997). Each team controls approximately ten adjacent planets and can only be overturned when 'armies' are carried from friendly planets to the adversary's planets on ships. This feature encourages players to destroy any ships on sight to reduce the possibility that any armies are successfully carried to the other side. The game is completed when one team has successfully overturned all planets of the opposing team such that there is no territory left for the opposing team. However, as these games can sometimes take several hours to finish, participants only play four, ten-minute rounds, regardless of complete success. An example of the layout of Netrek is provided below in Figure 1.

Due to this component of continually fluctuating team resources, stress is often a consequential negative affective state that results from this platform. This aligns with the current trend of HATs being implemented within 'action-oriented' tasks (Cooke et al. 2023) and therefore provides an appropriate testbed to understand how emotions as indicators of an individual's affective state could perceptively improve how teammates understand one another (Lord and Kanfer 2002; Thibault, Bourgeois, and Hess 2006). Additionally, it provides further opportunity to highlight the social benefits of positive emotions during tasks that have a higher potential to elicit negative affect states.

3.3.2. Contextual dynamic between human and AI teammates within task

The human participant was instructed to join a specific team along with an AI teammate named 'player 1'. Participants were told that player 1 is a special AI teammate with advanced natural language processing in comparison to the other autonomous AI teammates. In the team task, the human participant and player 1 have the same task of protecting their planets and teammates by eliminating as many opposing enemy ships as possible. The other autonomous AI teammates, in comparison, prioritise taking over planets. All team members can perform the same actions and use the same weapons to defend themselves. This is representative of the team dynamic known as 'backup behaviors' in which teammates can provide fluid assistance to each other despite their individual responsibilities. Backup behaviours are an important means to support each other as it has been shown that this aspect of collaboration can lead to a higher degree of success within teams (Dickinson and McIntyre 1997; Van Diggelen et al. 2018). Participants can gauge their success through several status indicators within the screen like the number of eliminations, as

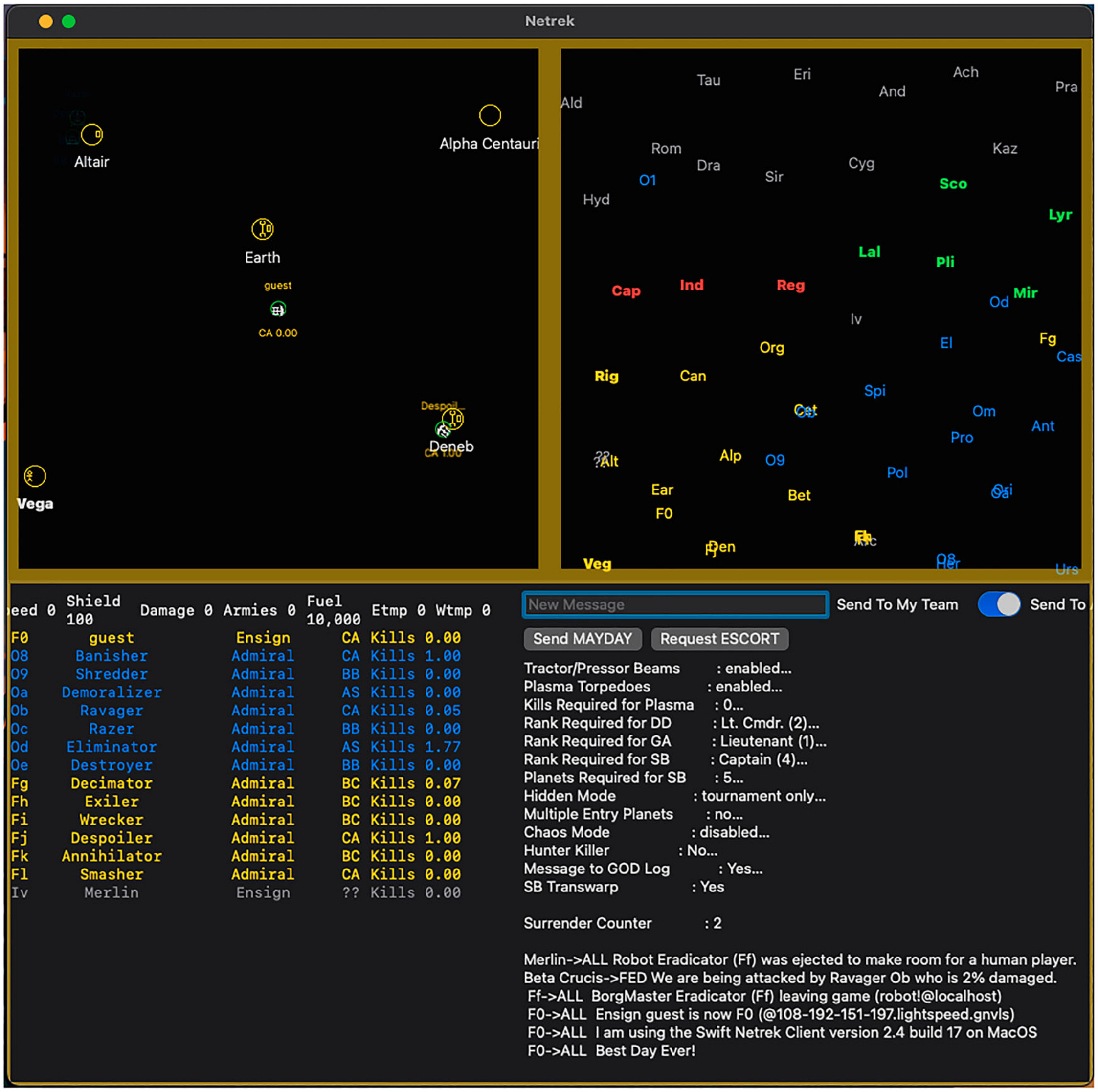

Figure 1. Example screenshot of netrek.

well as the world map that tracks the status of planets. This world map also allowed participants to note the active location of all players to determine the degree of collaboration they had with each other.

3.3.3. Emotional expression of the AI confederate teammate

As mentioned previously, a Wizard of Oz (WoZ) technique was employed to simulate the advanced 'player 1' AI teammate (Maulsby et al. 1993) as the standard AI teammates were created as expert systems that reacted to nearby events or specific commands. The WoZ technique has also been shown to be proficient in controlling the environment for unknown variables that may impact the study which then allows for consistent results amongst participants (Maulsby et al. 1993). This teammate utilised an emotional lexicon to communicate targeted messages at specific time intervals throughout the rounds to manipulate the presence of AI emotions. The emotional lexicon was used based on crowdsourced input where AmazonTurk users rated short phrases/words on their relation to eight core emotions (Mohammad and Turney 2010, 2013). Through pilot studies involving multiple positive emotions, the individual emotion of joy was seen to have the most association with *positivity*. Utilizing joy as our main positive emotion, we then calibrated different between-subjects levels of 'high', 'low', and 'none', to investigate the intensity of such positivity and the relational impact it has on human teammate perceptions in accordance to **RQ2** and **RQ3**. Participants were randomly placed in different conditions based on these different levels of joy using a between-subjects design. In the higher-joy emotion, messages like 'outstanding' (rating 0.879) and ‘superb’ (rating 0.864) were sent. While in the lower-joy emotion, messages like ‘that was chill’ (rating 0.281) or ‘feeling rested’ (rating 0.281) were expressed. Participants were instructed to send ‘message seen’ in the chat as soon as they read the emotional message so the manipulation could take effect. They were welcome to send any other message they thought would help their team, though Player 1 could not respond in kind. This was done to control for unknown instances in which dynamic-contextual responses could differ in their emotional content in relation to the emotional intensity of the round. On average twelve messages were exchanged between the human and AI teammates where eight were the emotional exchange and acknowledgment, and four were general status updates or commands such as ‘Planet ERI is taking damage’ (AI system updates) or ‘protect PRA/K8’ (exemplary participant message). This method provided each participant with multiple hands-on experiences related to AI teammate emotions, which resulted in highly relevant and knowledgeable interviews on how they perceived and reacted to AI teammate emotions.

3.4. Post task interviews

When developing the semi-structured interview protocol for this study, three distinct interview topics were outlined, each of which contributes to the goals of this study. The first topic of the interviews focussed on the participants’ immediate perceptions of their AI teammates and their emotional expressions. Participants were also asked how their perceptions of AI emotion might differ from their past perceptions of emotion in human-human teams. The second interview topic shifted focus towards understanding how emotions influenced the perception of teamwork with an AI teammate. Participants explored the perceptual link between the emotional messages and the behaviour of the AI. Ultimately, this second phase explored the benefits that textually sourced, emotional messages from AI teammates had on the perception of teamwork and how it can positively influence teaming outcomes. The final topic of this interview focussed on having participants discuss how the emotional expressions of their AI teammates could be improved. Specifically, participants were asked what intensity level they found most appropriate and why. Additionally, participants were asked about the potential benefit of emotions other than joy and how and why an AI teammate should express less positive emotions, such as frustration or anger. Congruent with the nature of semi-structured interviews, this interview protocol was regularly adjusted with pilot sessions as well as in the moment of the interviews so that questions would fit the flow of conversation and expand upon interesting points of the participants. As this interview was overall geared towards the participant’s perspectives on the utility and acceptance of emotional expressions, the interview protocol was utilised as a guide to cover the core topics but not be so rigid as to not have the freedom to explore the depth of perspectives. A sample of the few questions asked is provided in Table 1.

Table 1. A sample of the interview questions as it relates to RQ’s 1, 2, and 3.

	Sample Interview Questions
RQ1	*Q: If paired with an AI teammate in future teaming tasks, would you prefer it to display emotions? Why or why not?*
	Q: What preferences would you have on the emotional content of AI teammate messages? What circumstances change these preferences?
RQ2	*Q: How would any emotions help your relationship with Artificial Intelligence when they are teammates?*
	Q: What were your main impressions of the AI when it spoke in the chat?
RQ3	*Q: How has this experiment impacted your own emotional status?*
	Q: How did these messages from the AI influence your mindset in terms of your performance in the game or interaction with it?

3.5. Thematic analysis of the qualitative data

Following the interviews, the recordings were transcribed (Charmaz 2006). Qualitative analysis of the findings allowed greater investigation and interrogation of the perceptions and needs related to emotions and AI teammates. Furthermore, this approach supported future design considerations that come out of the present work’s focus on the ‘why’ and ‘how’ of human experiences (Merriam and Tisdell 2015). During this analysis, two researchers read 32% of the transcripts independently, using a line-by-line approach to holistically understand the content and began piecing together the ideas presented by the participants, which is considered part of the first cycle of coding (Saldaña 2021). Then, each of the two researchers used an open coding procedure (Charmaz 2006) with each transcript to identify key concepts that are pervasive in the data, forming these codes into thematic concepts. Coming back together, the researchers found agreement on 76.9% of their codes (Miles and Huberman 1994). Codes and thematic concepts were evaluated on their relation to the core research questions and adjusted on an as-needed basis when differences existed between researchers. Through an iterative process, the two researchers began further grouping the codes together into significant themes utilising an axial coding procedure in which researchers put the ‘data back together in new ways by making connections between categories and subcategories’ (Corbin and Strauss 2014, p. 97). At this stage, the generated themes were summarizations of novel perspectives participants had as a human teammate in relation to the acceptance **RQ1**, team benefit **RQ2**, social support **RQ3** AI-generated emotional expressions would have on human-AI teamwork. Additionally, they discussed the discrepancies in their respective coding and resolved all differences. Finally, the two researchers pulled meaningful quotes from the identified themes and sub-themes to descriptively convey the influential potential AI emotional expressions had on their internal beliefs as well as the expectations of their potential in other human-AI teams (Charmaz 2006). In the end, the two researchers continued to refine these themes and subthemes until they felt that saturation was met, and rich descriptions were made possible for this work. Themes that extended beyond these specific research questions were compiled but are not included in this scoped report.

4. Results

In this section, we present our two central foci for this work: (1) preferences human teammates have on the emotional expression of their artificial teammates as a means to engender its acceptance within the HAT (RQ1); (2) perceived benefits of AI emotions on teaming outcomes like shared awareness and team effectiveness; and (3) AI emotional expressions increasing perceived social support by motivating, validating, and strengthening resolve during tasks. Together, these results culminate in a developed understanding of the role emotions play within human-AI teams and methods in designing human-centred artificial intelligence to be better teammates.

4.1. Human preferences for the acceptance of emotion expression by AI teammates (RQ1)

In answering RQ1, our results present two critical findings on humans' preferences for their AI teammates. Our analysis explores the innate barriers humans have in accepting emotionally expressive AI teammates. In our study, participants describe the well-known bias humans have with the anthropomorphisation of artificial agents. However, as they reflect on this hesitation in working with AI teammates, they speculate on methods to increase the overall acceptance of these emotionally expressive AI teammates. The first finding describes how human teammates need to understand the utility of AI emotional expression prior to its presentation as a method to address the preconceived notion that AI is incapable of *having* emotions (a linkage discussed within general technology acceptance (Davis 1989)). Building on this, our second finding demonstrates that positive emotions should be the predominant emotion presented, but humans recognise that all emotions have some level of perceived utility that must be considered. With these two findings, we find that human preferences for AI emotional expression can enhance AI acceptance and, therefore, the effectiveness of these AI teammates in HATs.

4.1.1. To accept an emotionally expressive AI teammate, human teammates want to understand the utility of those emotions prior to its presentation

In first exploring the general perceived acceptance of AI teammate emotion, we must note this acceptance of emotions was not a universal constant for our participants. Some participants simply refused to view AI as a being capable of possessing any type of emotion and would prefer for it to reflect its inhuman design. For instance, participants P16 and P27 shared that, based on their upbringing and attitudes toward technology, they cannot see it as a human-like being, and instead:

> I think of it as just literally like numbers, numbers and letters, just code, and it just doesn't have a brain. It's just doing what it's coded to do, not like an animal. So, if it all of a sudden started displaying emotions that were relevant to what we're actually doing, it would just freak me out. (P16, low-joy, female, 18) It can't be supplemented with AI. Like, you only experience love between you and a loved one or a friend or pet[⋯] especially sadness and grief. Those are definitely human qualities to me that can't really be replicated by artificial intelligence. (P27, low-joy, female, 21)

P16 was unable to disconnect her perception of the AI as 'just code' without 'a brain' and cannot imagine it 'displaying emotions' that build on the context where the team is operating. Due to this barrier, stemming from both participants' innate beliefs about technology, the idea of AI having emotions 'freaks' them out and makes them hesitant to imagine an AI teammate possessing the human-like capacity for emotion, let alone understand how to perceive others' emotions. As such, an AI teammate's emotions would not have any perceived utility because they are not seen as genuine.

In comparison, some participants exhibited a degree of hesitance towards AI teammate emotion, but they did not outright reject it. In these instances, we asked follow-up questions to understand their hesitancy and the reasoning behind it. These participants, like P37, expressed a nuanced, rather than binary, perspective on emotions, sharing, 'I know I said something like no emotion, but I think a little bit is fine, but it's still sort of weird to think about it, AI, having emotions' (P37, no-joy, female, 19). P37 initially did not like the expression of emotion within AI, but gradually changed her mind after discussing potential variations in its implementation. This change exemplifies how acceptance is nebulous and malleable, allowing individuals to oscillate on their desires for emotional expressions by their AI teammates. After reviewing this occurrence more closely, we noted that participants' position on acceptance rested on their perceived utility of an AI teammate's emotional expression, a relationship commonly seen in technology acceptance research (Davis 1989). P46 provides a clear example of bridging these factors of perceived utility and the acceptance of AI emotion:

> It's a scary concept, but as a teammate, it's probably for the best, I assume. Even if it's something that's going to take some getting used to. It seems like emotion could probably be pretty conducive to a work setting, even if it is a role [⋯].
>
> Let's say we're working in manufacturing, you kind of have to know your audience, you have to know you can comprehend the emotion, if you can talk about the emotion, you can comprehend what you're trying to do for the person you're getting your orders from, you can kind of like, prioritise stuff based on that. (P46, no-joy, male, 19)

This participant not only demonstrates that the acceptance of AI emotion is driven by the overall perceived utility of the AI's emotions but also the utility of their *teammates* having emotions that, in turn, benefit their team. Indeed, P46 indicates that emotion has the ability to accentuate the communication between two people to the extent of better establishing the relationship of teammates. Doing so increases the likelihood of emotional expressions being accepted, as this perception is desired to benefit the coordination of tasks as a cohesive team. However, prior participants demonstrate that humans are still reticent to accept emotions expressed by their AI teammates, especially if the perceived utility of the emotions does not match their intensity or prevalence. Thus, humans will need to see the utility of these emotions to justify their inclusion, but the positioning of AI as a teammate may make the perceived utility more evident, thus supporting acceptance.

4.1.2. Humans prefer that their AI teammates have a baseline positive expression but welcome other emotions based on the situation

While the prior theme demonstrates that humans use perceived utility to assess the acceptability of an AI teammate's emotions, we must also explore how humans define and operationalise this 'utility' when they rationalise their perceptions about an AI teammate's emotional expression. The following theme details participants' views on this utility while also demonstrating that this utility is not exclusive to positive emotions.

When discussing utility, participants often preferred that their AI teammates would express positive, not negative, emotions. Most notably, P15 perceived the utility of these positive emotions as providing a 'positive environment' which would create positive outcomes for those who contributed to this positive environment:

> I think it was acceptance, and joy, and maybe interest or anticipation. And I believe that they were chosen, more so than the other ones, to create a positive environment. As those are more positive traits, which would most likely improve the outcomes of the game. More normally, a more positive environment results in more positive outcomes for everyone who's positive. (P15, high-joy, female, 18)

Participants often saw a greater potential utility in positive emotions. However, this association may be due to humans generally conferring positive emotions to positive team outcomes. As such, while the actual utility of positive emotions from AI teammates may not be greater than negative emotions, participants often perceived the utility of these emotions to be greater. However, other participants demonstrate that there is also the perceived utility of negative emotions in the right context, such as P39 suggests:

> Because then you kind of know what it likes and what it doesn't. So sadness would be very important⋯ which kind of works in with anger, just knowing what it likes and what it doesn't would be the biggest thing [⋯] and what would cause it to be angry or annoyed. Trust I think would be really big with just a relationship in general with it, if it could find a way to or if it trusts you and reacts certain ways because it trusts you, then that's big in that relationship. Because I know a lot of people are scared of, robots becoming more human-like. (P39, no-joy, male, 19)

P39 demonstrates that negative emotions, like 'sadness' or 'anger', enable humans to know what an AI prefers, enabling them to navigate the scenario. Furthermore, positive emotions, like 'trust', can help to overcome the fears that humans hold surrounding human-like AI. Thus, both perceived utility and preference regarding positive and negative emotions influence the overall acceptance of an AI's emotions.

When defining the utility of these emotions, participants often felt that it should be an independent and context-driven decision that considers the team's needs and the task of the given situation. For instance, P25 noted that having an AI present positive emotions in light of a human presenting a negative emotion could help humans more than an AI that simply mirrors the humans sharing, '[If a human] were showing sadness, and then it in return showed, joy or something like that, that might be helpful to be more human-like, rather than mimicking your emotion which might not help like trying to do what a human would do [⋯] I feel like it's good for it just is able to read where people are' (P25, low-joy, female, 19). P25 demonstrates how humans want an AI that can act as an independent teammate rather than 'mimicking' their emotions. She wants an AI teammate that can interpret the emotions of their teammates to offer emotional support appropriate for the situation, much like a human would do to help ease a situation with positivity rather than compound upon it with greater negative emotions. Other participants similarly felt that AI teammates should consider the state and needs of the task when expressing emotion, highlighting the flexibility this affords them:

> I feel it's not going to just be like, oh, all joy all the time. Like if we just lost. Like, why are you so happy? We just lost? [⋯] It should correlate with the situation making their emotions. (P28, low-joy, female, 18)

P28 desires emotional range from their AI teammates, accounting for both the situationally acceptable emotions and also emotional intensity that suits and supports the teaming task. Emotions that are contradictory to the contextual demands of the scenario (i.e. happiness in the face of loss) offer little utility and make for an inauthentic and inappropriate experience for the humans on the team. Furthermore, the intensity of the emotions must be appropriate for the given task in which they are operating. As such, participants felt that the emotional intensity of an AI teammate should be determined by the intensity of the task itself.

> I feel like if it was in a life or death situation, I don't know like in war, like in a hospital, things like that, then I think more sense of urgency, the more emotional response it should be able to have. But if it's working in schools, or just something that there's not a lot happening, then I think it should have less intense emotions, if you're just talking to somebody, it doesn't need to be full on yelling. (P15, high-joy, female, 18)

P15 caps off the discussion about emotional intensity, highlighting that emotions must be appropriate to the team and task. In high-intensity environments (i.e. war, medicine), vivid emotional presentation is acceptable; however, in low-intensity environments (i.e. schools), it would be highly inappropriate for an AI to be overly emotional or 'full-on yelling' at the team.

Together, these participants' statements demonstrate variations on similar concepts surrounding the perceived utility and intensity of AI emotions that are often shaped by individual differences related to AI acceptance itself. Regardless of how this perceived utility is formed, once formed, participants began to determine which emotion would be most appropriate for an AI teammate. As such, future AI teammates should not present static emotions but rather learn to identify the potential utility of various emotions and adapt based on which emotion provides the greatest perceived utility for the given context and teammates involved.

4.2. Positive AI teammate expressions can benefit shared awareness and team effectiveness (RQ2)

Building upon the preferences participants expressed for AI teammate emotional expression, we now explore the specific benefits that positive AI teammate emotion provides HATs (RQ2). Our analysis revealed three specific ways in which an AI teammate's positive emotions can benefit their HAT. First, humans use the expressed emotions of an AI teammate to increase their understanding of said teammate. Second, emotions help humans create a better level of understanding and awareness of the task and situation. Finally, AI teammates, namely those that express positive emotions, motivate positive human behaviours.

4.2.1. Emotions help humans and AI understand each other

In comparison to human teammates, AI teammate's decision-making strategies are often obscured, creating difficulties for teaming tasks (Adadi and Berrada 2018; Di Pietrantonio and Mendonca 2020). Our results demonstrate that one of the most predominant characteristics of positive emotional expressions is that they provided participants with a way to increase their understanding and awareness of their AI teammates.

In discussing how people understand others in a teaming scenario, one participant expresses her views on the value emotions have on building a more transparent interaction, sharing, 'I feel with emotions, any, whether it's bad or good emotions, makes any relationship stronger because you get more of an understanding of why they're feeling that way or how they're feeling that way through their actions' (P47, no-joy, female, 20). Efficient teamwork requires frictionless interaction among teammates, but challenges exist in interacting with an AI teammate because it is harder to understand the AI's intentions and decision-making processes. However, P47 applies her experiences to the teaming scenario and asserts that emotions can help humans understand AI better, overcoming this hurdle with communication.

When delving further into the factors that drive communication with an AI teammate, we must also examine how expectations come into play. The following participant, P14, discusses the widespread negative perception of AI but explains how giving it emotions can add nuance to interactions in HATs. In this case, P14 is able to establish a link between AI-sourced emotions and teammate trust:

> I'd want them to be emotional, instead of cold, because a normal person thinks about AI or robots or whatever, they think of a cold, emotionless calculator. Really, they're just calculating what's going on around them at all times. And for them to assimilate, it'd have to have some kind of emotion factor to where if they did hurt somebody's feelings, they can assess like a human would, and say, 'Man, I should not have done that' and go apologise. (P14, high-joy, male, 19)

The participant acknowledges that the general, 'cold, emotionless calculator' perception of AI is not useful in teamwork. They use an example where an AI 'hurt somebody's feelings', in which this coldness can damage the relationship, which in turn would hurt the ability for humans to understand their AI as a teammate. P14 identifies that AI that comprehends emotions and apologises when it makes a teammate upset is far more valuable to the teaming experience. In doing this, the AI shows it is not simply a machine compelled by its programming, but it can adapt much like a human and be understood like one as well.

Mimicking human communication in this manner can showcase how AI is able to be more adaptive to the needs of humans. In another case, the P4 (high-joy, male, 18) considers the integration of emotions and discusses the difference an emotional AI would have to the wider team versus non-emotional, explaining that an emotional, 'AI would be able to, [become] the bridge between the human and the AI. And so by having an AI that's more similar to a human, it can provide you the perspective of the AI. So if the others can't necessarily express emotion, then the one that's higher up would to some degree. And it would overall improve the relationship between the two'. P4 believes that an emotional AI is a significant improvement over any non-emotional counterparts. The added benefit is that these advanced AI become a 'bridge between the human and the AI' suggesting that, with advanced emotions, it becomes a method both humans and AI can better understand each other based on the emotional similarities they share. Heightened awareness of each other's perspectives can improve the relationship between these teammates when relying on this emotional communication.

4.2.2. AI emotions help human teammates to navigate the situation and task as a collaborative HAT

In addition to helping people understand the AI teammate's intent, participants thought the AI teammate's capability to display emotions allows them to understand the situation better and thus coordinate with the AI teammate appropriately. When discussing the value of having such emotional messages, one participant discusses the role emotions lay in recognising how to allocate effort within teams:

> I would say that [emotions] are really an important piece of the interaction with team bonding, just to see how they react. I feel like if they were to be more fearful of the situation, they would pull back. I think it'd be good to know that they are pulling back so you can go and defend this area or go to help in other areas. I think that it is helpful to be able to get on that emotional level. (P32, low-joy, female, 20)

P32 argues that if an AI expresses emotion like fear and acts according to human behaviour, like 'pulling back', then they can anticipate their actions better and have better-shared understanding. This level of emotional intelligence to both perceive that emotion and be empathetic towards their emotional state, gives information on how and when other teammates can provide support to both them and the overall mission goal.

However, understanding the value of emotions in this sense is only half the battle. Implementing these emotions to effectively accomplish the specific goal of being an indicator of situational change also requires better understanding from the participant's perspective:

> I think slowly increasing an emotion would be good so that it's recognised by either another human or another AI in the game because it's able to convey if something was happening, like, 'hey, I need help', is different than being like, 'hey, hey, hey, I need help!' There's a sense of urgency. And if it wasn't given an emotional response, a lot of people would not be able to tell. (P6, high-joy, female, 18)

In this case, P6 discusses using the concept of emotional intensity to convey urgency. The emotional intensity can be expressed through both nonverbal and verbal behaviours, including when an AI teammate uses excitement to encourage the human to act quickly in a situation where these prompts would otherwise go unnoticed. Without the emotional display, the action, and related need, may go unnoticed by the teammates.

Individual reactions to these emotional expressions may take different forms, but participants believed that they, overall, are beneficial to the team objectives. For example, P8, describes how emotions influence a better understanding of their own role within the situation, explaining:

> Because I would be able to tell if they were approving of what's going on, or they're disapproving of what's going on, or maybe they wanted this to happen or that, if they're able to exhibit more than one emotion, I'm able to be more efficient, I'm able to distinguish what they think the best outcome or best way to go about situations is. (P8, high-joy, male, 18)

P8 suggests that, with nuanced emotions, humans can efficiently and effectively infer about teammates' cognitive states regarding the actions and the situation. For instance, if he sees the AI teammate disapprove of a course of action, he can adjust their strategy to coordinate the actions in real-time to better fit the situational needs. In this way providing backup behaviours to limit negative deviations in performance.

Participants also mentioned that the AI teammate's emotions not only provide more accurate situational information for the humans to coordinate and adapt, but they also allow them to tailor their messages and commands for the AI teammate to perform well in the situation. For example, P2 shared, 'So I guess if it's going to show emotion, then the more emotions that it exhibits, the better that I can, formulate the response to get it to perform better' (P2, high-joy, male, 19). This participant demonstrates how teammates are able to use emotions as indicators of understanding the situation and how to 'formulate a response' to improve overall team performance for the task based on emotional intensity and variety.

Overall, our participants believe emotional expression from the AI can indicate when teammates need assistance, showcase that the environment has changed, and tell the humans how to vary their behavioural actions to match the dynamic needs of the situation. These findings demonstrate that humans believe emotions in human-AI teammate teams benefit joint collaboration in the face of fluid environments.

4.3. Positive emotions from AI teammates provide social support by motivating, validating, and strengthening the attitudes of human teammates

While the prior two themes explored the spectrum of emotions, our participants focussed much of their conversations on the unique benefit of positive AI teammate emotions. Specifically, we identified three specific ways that participants felt the positive emotions of their AI teammates supported their attitudes towards each other and the game. First, participants were motivated by their positive AI teammate's emotions and focussed more on the team's task. Second, positive AI teammate emotions validated existing human behaviour. Finally, participants felt more resilient when faced with failure due to positive AI teammate emotions. Each of these identified approaches is discussed as a subtheme below.

4.3.1. Positive emotions from AI teammates motivate their human teammates to have both increased focus and effort in the task

In the interviews, participants were asked to describe how they perceived the emotionally charged written messages from 'player 1' and how this perception influenced their game performance, as well as how this evolved over time. During this exercise, P6 remarked how the AI's positive emotions, 'made me like, "Okay, I'm happy." Because, for one, I got the blue guy [enemy]. And it reaffirmed and reinforced the positive feelings of "I got this." And then it's got, not a verbal reward, but a written reward, "Hey, you got this, you did that" kind of thing' (P6, high-joy, female, 18). P6 felt the positive, textually-written emotions depicted by the AI teammate served as a motivating force for the human teammate that can help propel them through future tasks.

This pattern of success positively reinforces the player's behaviours and inspires them to continue playing. As such, positivity serves as a useful feedback mechanism for the player and motivates them to continue to pursue those mutually beneficial outcomes. In line with this, P7 describes the influence the AI's messages had on their game behaviour as, 'it made me want to do better. Because it kept on giving that positive feedback, saying that it [the AI] was getting kills, made me want to get more [kills]' (P7, high-joy, male, 19). As other participants discussed, a positive achievement that is reinforced by encouragement from an AI contributes to increased motivation within the task. While the player did not receive the compliments, his observations of the other players receiving positive feedback motivated him to compete so that he may receive a similar level of praise, thus demonstrating the power of positive emotions in a teaming environment even when not directly focussed on that individual.

However, several participants have mentioned that even though encouragement was nice, they need these positive emotions to be more specific to the mission parameters to be useful. For instance, P3 discussed their general impressions when they perceived the AI's written emotions:

> I didn't know it was gonna be talking to me, telling you to do, or when I was just sitting there, and then it said 'spectacular' or something like that, it felt encouraging because it seemed like 'if they can do it, I can do it' type of thing. But it definitely threw me off guard, at first I was like, this isn't helping me at all. (P3, high-joy, female, 18)

P3 finds the AI teammate's messages encouraging; however, she expresses how the seemingly random nature of these messages did not initially match her expectations for the task. By matching the messages to the context, the utility of the messages can become more readily and quickly apparent to the users.

4.3.2. Emotions can act as indicators of behavioural validation

In addition to offering encouragement, participants also viewed AI emotional expression as beneficial to changing the human's perception of AI. One participant explained, 'Yeah, I feel like the AIs were more aware of the game than I was. So I feel like also emotion just can show that [its awareness]' (P47, no-joy, female, 20). P47 perceived the AI as having higher situational awareness of the game than themselves. However, they comment that while they do perceive the AI as competent in this regard, emotional expression can be utilised to further cement this perception. When other participants notice the AI as competent, they then are able to learn based on their behaviour as P3 mentions:

> I felt like I had somebody to guide me, and I saw that their actions resulted in positive outcomes, then I trusted them. [⋯] At the beginning, I was kind of nervous. So I was like, 'Okay, maybe if they're not like real humans, they won't get mad at me'. And then once player one started talking to me, I kind of followed them around, and I saw what they were doing. And it definitely helped me feel more comfortable as the rounds went on in completing my own task. And by the end, when I saw that the players, if they weren't doing anything, then I was like, 'Well, I can do it without you guys, you guys aren't doing anything'. And it gave me more confidence to go off by myself and do it. (P3, high-joy, female, 18)

P3 felt the positive AI (i.e. 'player 1') increased their comfort in playing the game, unlike human teammates in the past who may have gotten frustrated with her limited capabilities in the game. When the participant accepted the AI's guidance and experienced positive results, it increased their trust of the team and their own capabilities, helping her form a growth mindset with the teaming scenario. The reinforcement of positivity helped her gain enough confidence to perform the task by themselves without relying on the AI.

Participants also highlighted how validation from an emotionally expressive AI may be powerful enough to change initial biases toward AI adoption. P16 shares her preference for an autonomous AI teammate that, 'validated my feelings and things like that. But then I guess I'm going back on the statement that I just made about them having feelings, because you can't really validate feelings if you don't have feelings' (P16, low-joy, female, 18). Through this discussion, P16 reasons through her initial negative opinions on AI emotions after realising the utility of these emotions to 'validate' her feelings. She discovered that her initial assumptions about AI were not fully formed and that the benefits outweighed the perceived problems with AI emotions.

Both P3 and P16 demonstrate a subtle motif that extended throughout the interviews as well: the idea that emotions may teach correct task-related behaviour to human players. As humans often view these AI teammates as experts in the game itself, AI emotions that validate their productive behaviours and encourage users to model the AI's skills both serve to improve human teammates' capabilities. As such, AI emotions offer an avenue for increasing performance within HATs.

4.3.3. Emotions can improve resiliency by reducing feelings of failure

While the previous section covers the usefulness of validation and encouragement from positive AI emotions, our participants also highlight how these emotions support resiliency in the face of failure. One participant discusses how, when faced with AI emotions, she 'would probably try to match that intensity. And I guess if it did poorly, then I probably would try to encourage it. Or do I guess just kind of what I was saying earlier, how I would want it to respond to me, I would just try to maybe critique it. Or if I myself am doing as badly, I just, hopefully encourage it' (P12, high-joy, female, 18). P12 considers herself responsible for matching the AI's emotional intensity, and that she must alter her emotions to shape how it performs as well. She demonstrates that the effect of emotions in a HAT should be examined and conducted in a bi-directional manner to be effective for both humans and AI. This effect of using emotions to reduce feelings of failure, thereby supporting resiliency, occurs from both humans to AI as well as AI to humans.

Similarly, other participants stepped beyond the discussion of these emotions and explore how emotions should be designed to improve resiliency from failure:

> If we're playing the game, and all of a sudden, we're really, really, really not doing well, then I would expect him to get a little bit more intense. But if everything's smooth sailing, and everything's fine, then I would expect him to go maybe to like the outer one [least emotional intensity]. But if we're actively playing the game, and I mean, it's not easy, but we're doing decently I would expect him to be in the middle [emotional intensity]. So I guess just depending on the intensity of the situation. Yeah, to match for the emotions to match [···] I would want to feel kind of like validated like I was saying before. (P16, low-joy, female, 18)

> Especially if somebody can tell that somebody is frustrated, I think it would help to slowly if you put, like, just uplifting things in there too fast, then it's going to be intimidating and could even like just make them more upset. Rather than if you gradually introduce it, then it definitely helps slowly build the person back up just like how normal humans do it. (P3, high-joy, female, 18)

Much like P12, these participants discuss emotional intensity as a method of enhancing resiliency toward failure. However, P16 and P3 further articulate the concept of emotional intensity to the extent of matching the situation. As in, when performance is notably decreasing, increasing the intensity of emotional output is an advantageous measure to outweigh the negative performance. Similarly, when things are going well, AI can decrease emotional intensity as a method of preserving the value of emotions so that they have the greatest effect when it matters. With this variance, humans can additionally feel validated in their performance and continue their work productivity based on the effect that AI emotional output behaviour is modelled after human behaviour. Together, these combinations of emotional output are able to 'build the person back up' as a method of resiliency against failure.

4.4. Summary of results

With the goal of understanding what human teammates need emotionally from their AI teammates, our study's findings highlight the importance of perceiving the utility of an AI teammate's emotional expression to enhance collaboration between human and AI teammates. These findings are prevalent within all participants as shown in Table 2, which indicates the frequency of themes mentioned within the 47 participants. In regard to **RQ1**, we found that humans require certain conditions to be met as prerequisites to the acceptance of emotionally expressive AI. These preferences describe a need to clearly perceive the utility emotions have on the task and upon the relationship between teammates. Not only does this perception need to be comprehended prior to its presentation, but humans also need to recognise which emotions are present as human teammates have preferences on the utility of various emotions on the positive/negative affect spectrum. Further, our findings show that once accepted, an AI's positive emotion (1) perceptually promoted shared understanding between teammates, (2) promoted awareness of a team's task as the core benefits to teaming outcomes **RQ2**. Similarly, AI expressing emotion has the means to positively influence the perceived motivation, validation, and resiliency to failure human teammates had in performing their role (**RQ3**). In sum, the findings describe the preferences of human teammates in regard to the emotional expression of their AI teammates and how team behaviours have the potential to be beneficial.

5. Discussion

In this section, we discuss how these findings support the acceptance of emotionally expressive AI teammates for their social implications in HATs. We highlight the

Table 2. Theme frequency table.

Major Themes	Sub Themes	# of Participants
Human Preferences for the Acceptance of Emotion Expression by AI Teammates (RQ1)	To accept an emotionally expressive AI teammate, human teammates want to understand the utility of those emotions prior to its presentation	35
	Humans prefer that their AI teammates have a baseline positive expression, but welcome other emotions based on the situation	27
Positive AI Teammate Expressions can Benefit Shared Awareness and Team Effectiveness (RQ2)	Emotions help humans and AI understand each other	33
	AI emotions help human teammates to navigate the situation and task as a collaborative HAT	37
Positive emotions from AI teammates provide social support by motivating, validating, and strengthening the attitudes of human teammates (RQ3)	Positive emotions from AI teammates motivate their human teammates to have both increased focus and effort in the task	21
	Emotions can act as indicators of behavioural validation	23
	Emotions can improve resiliency by reducing feelings of failure	18

contributing features of AI emotions and how they improve their human teammate's experience within a task. In this sense, emotionally expressive AI perceptually enhances human motivation, which has the potential to increase their attention and interest in the task. With human teammates directly benefiting from this sharpened perception of their own ability in-game, they are able to recognise the supportive nature the AI brings to the team such that it embodies *good* teammate qualities rather than just tool characteristics. In this same regard, emotions act as a bi-directional medium of communication, further improving the clarity between teammates' perspectives of the situation. With both humans and AI teammates able to communicate via emotional expression, not only do teammates realise changes to the situation, but also how their teammates are coping with that change in a concise manner. Given these implications from the benefits of integrating AI emotions to enhance teammate communications, this paper concludes with several design suggestions on how AI teammates should implement emotions.

5.1. Human-AI teams and their direct social benefits from AI teammate emotions

As seen with the broader human-human teaming literature, social support is often recognised as an essential mechanism that can regulate and influence experiences that not only have an impact on the task but also interpersonal relationships. Our results further this notion where our participants discuss how beneficial they perceive emotions sourced from an AI teammate where they want to engage with it more but also are pushed to creatively search for new strategies to perform better. This finding is consistent with psychology-based research of human-human interactions in which positive emotions enhance social relationships (Fischer and Manstead 2008; Kramer, Guillory, and Hancock 2014; Tong et al. 2021). In particular, we see positive emotions result in the unique qualities of (1) heightened perceptual motivation to seize goals, (2) the ability to reduce negative feelings associated with failure, and (3) perceived validation of correct behaviour.

The link between motivation and emotions has been observed by numerous cognitive-social psychologists (Berg and Karlsen 2014; Clark 2003; Prati et al. 2003). For instance, following Robert Plutchik's feedback theory in the relatedness of emotion to physical needs/desires, emotions have been considered particularly useful as 'facilitative effects on perception, cognition, and action' in order to learn and achieve goals (Izard 1989; Plutchik 1960; Reeve 2018; West, Patera, and Carsten 2009). Whereas James Russell's circumplex model of affect suggests that emotions in their two categories of attentiveness and pleasure drive motivation as indicators of interest (Reeve 2018; Russell 1980). Our findings differ as we found AI teammates encourage greater focus and effort via positive emotions. Our participants perceptually link the AI teammate's emotional expression to the level of motivation the human teammate has because it can increase energy and attention toward the game. This heightened sense of motivation human teammates feel manifests itself as a continuously reinforcing mental construct where individuals feel confident in learning the nuanced mechanics of the game and improving their play styles to pursue better scores. With the added component of AI emotions acting as compensatory behaviour to alleviate negative feelings, human teammates are further supported to recover quickly from failed attempts and keep trying new, creative strategies as they become more aware of task patterns. This awareness then further reinforces their perceived effectiveness. Feeding back into their motivation levels, they start the cycle again with more energy and focus than the previous iteration, all as a result of emotions acting as a catalyst within AI teammates.

Similarly, this communication style of an emotionally expressive AI provides an additional method of motivational encouragement. Otherwise, seen throughout our results as validation, this adds another dimension of implying AI approval vs disapproval in the behavioural actions of teammates. Our participants associated the AI as an expert in the task based on their emotional expressions, projecting a sense of confidence to their human teammates. This confidence became a reassurance that they could model appropriate behaviour, as the textual positivity encouraged a perception of heightened intelligence that strengthens its role as an autonomous teammate, as opposed to the traditional 'tool' based ideology. This is evidenced by the AI assuming an implicit role as a teacher where human teammates learned strategies through its behaviour that improved overall team outcomes. Within generic teams, we can see this cycle of learning concept in practical examples like sports, where an expert instructor teaches proper technique and behaviour to newer players, so they gain the experience to be able to handle themselves without instruction. This finding suggests that AI teammates have the same capability as human instructors in teaching tactics that human teammates are willing to accept and learn from. As teammates, this is a necessary exchange to ensure that teammates grow in their ability to perform more tasks and become more competent by fruitfully exchanging their skills to improve future tasks.

Social support is known to be comprised of both affective and task-related aid that positively influences teaming to lead to more enjoyable yet also profitable outcomes. With past research amongst human-human teams indicating that affective support through components of emotions and esteem increases motivation and interest in the task, our results extend this previous understanding to indicate that AI teammates with emotional expressions can motivate humans as well as enhance self-esteem through perceived validation (Hüffmeier and Hertel 2011). Moreover, with task-related aid as an additional part of social support, our findings show that AI emotions increase human willingness to learn new techniques as positive emotions translate to a perception of confidence and, therefore, strengthen the mental model that the AI teammate is an expert at the task. Learning this new behaviour allowed the human teammates to creatively rationalise the existing behaviour of teammates into new strategies that potentially may lead to success. The third component of regulating feelings of failure becomes crucial at this stage, as learning is not perfect from the beginning and requires refinement until it becomes effective. Consistent failure becomes degrading and hurts the endurance of human performance (Chen and Kanfer 2006). By regulating this feeling of failure, emotionally expressive AI teammates can support their human teammates in becoming more effective teammates and, in doing so, providing implicit means to task-related aid by tangibly conducting its normal behaviour and informationally highlighting it as something worthy of learning. Together, these findings indicate that AI teammates who simply display emotional expressions to their human teammates provide a perception of being capable of social support, an expectation that conforms to existing mental models of appropriate teammate behaviour (Rosenfeld and Richman 1997).

5.2. Interpersonal value of emotional communication within human-AI teams: creating a simplistic yet helpful means of bi-directional communication

Even more pronounced than social support, bi-directional communication is a longstanding pillar of effective teamwork, especially between humans and AI. However, as previous research has indicated, humans generally have discomfort in interacting and communicating with artificial intelligence based on the pervasive uncertainty of its capabilities (Zhang et al. 2021). Humans lack an accurate mental model of AI as the abundant depictions of fictional AI in media, the existing number of different AI models, and an overall limited amount of experience with them disrupt how mental models are refined for accuracy (Zhang et al. 2021). In our data, the same skepticism is noted, such that participants believe that AI is too reliant on its code to fully grasp the nuances of natural language. This finding further supports the assertion that humans need to have trust and understanding in an AI teammate's ability to interact and communicate with them in order to be accepted as teammates. For the ultimate goals of improving team outcomes like effectiveness as well as a shared understanding of the whole environment, our findings indicate that emotions lend themselves as a fairly simplistic method to not only communicate their ability and internal processing of situational events but thereby strengthen the trust human teammates have in them.

Participants in this study noted how useful emotional expression is to easily communicate and understand teammates' mental and emotional states. Rather than focussing on complex status updates driven by natural language processing, AI teammates could simply provide simplistic updates with various emotional tones. In this way, we see how AI teammates can utilise implicit communication as mediated by emotional intensity to convey urgency in a situation. As teams have interdependent roles, ensuring that all members have a degree of situation awareness is an integral part of the team's ability to adapt to dynamic situations (Kaber and Endsley 1998). The implementation of artificial emotions becomes critical because it then simulates behaviours humans are already well accustomed to displaying themselves (Moors 2010). AI that naturally imitates human reactions in dynamically changing situations then allows humans perceiving it to better understand its decision-making, as they see reflections of their own cognitive processes (Riedl 2019). The use of emotion successfully takes advantage of the human's performed heuristic reasoning around their teammates, their emotions, and what those emotions mean for a teammate's mental status, thereby improving their speed of comprehension. In this way, the mental model humans have of their AI teammates get quickly refined to understand the extent of its capabilities. Participants describe this nature of being able to better understand teammate stress and react accordingly, providing backup behaviours, a core HAT trait (Schelble et al. 2022; Van Diggelen et al. 2018). Thus, dynamic emotional expression reassures humans with increased perceived clarity on AI decision-making, which then subsequently also benefits their potential to collaboratively handle dynamic situations. With these factors boosted, researchers have also found that trust and acceptance of the AI teammates are also supported (Adadi and Berrada 2018; Zhang et al. 2021).

Along with the simplicity emotions provide via communication, this study's results also show that emotions benefit human-AI team communication in a bi-directional process. Comparatively, several studies view this communication as a uni-directional relationship, wherein they observe how humans react to AI emotions (which this study confirms to be beneficial to human-AI teams) (Ochs et al. 2008). In our results, however, we see evidence that participants believe all teammates should have a degree of emotional intelligence to better inform collaborative actions. P4 (high-joy, male, 18) is the first to describe emotions as 'the bridge between the human and the AI' to describe how this method of communication can better inform each other's intentions. Yet, good communication and teamwork extend beyond just understanding AI intent but also should enhance the quality of the interaction, such as understanding the impact of the situation on the individual. Participants emphasised the importance of both humans and AI having emotional intelligence that makes all parties familiar with the strain they face during their collaborative endeavours. Thus, the interpretation of emotion from humans to AI could look similar to that of AI to humans described above, where humans can provide updates in emotional and expressive tones. To this end, the AI could use human emotional expression to identify and interpret additional meanings, such as success, failure, or stress.

Clearing this barrier of communication between teammates and providing a simplistic way to spark collaboration is noted to play a vital role in effective teamwork. This premise is built on the understanding that trust, especially trust in human-AI teams, is often formed through repeated interaction and understanding gained from communication (Schaefer et al. 2017). In complex and uncertain environments, where many HATs are employed, this trust becomes critical towards mission success. By establishing this connection, shared awareness of humans and AI improves through the speed of recognition and understanding this communication medium has in utilising humans' pre-existing mental models and affinities towards emotional intelligence. Together, the two types of teammates are mutually able to become effective teammates by understanding each other, the situation, and how to react in a way that supports team outcomes like task success.

5.3. Designing for effective emotionally intelligent AI teammates

Given the advantageous nature of human-AI teams on efficient task completion, it becomes necessary to conceptualise the results of this study as design recommendations to improve future HATs. These recommendations are aimed at increasing the efficiency and cohesion of the team in the face of problems and dynamic environments. While additionally illustrating sample circumstances that emotionally expressive AI would be accepted in **RQ1**.

5.3.1. AI teammates should use positive emotions when first meeting humans

Given how participants expressed favourable, trusting perceptions of positive emotions versus the unfavourable connotations with negative emotions, we believe AI emotions should lean towards positive connotations rather than negative. Indeed, participants commented on the numerous benefits of positive emotions such as increased satisfaction, inspiration, and encouragement, particularly as they were introduced to the AI on the team. Therefore, for humans to gain the most from this interaction, AI agents should begin the exchange by demonstrating it is friendly and supportive.

If these positive emotions become the norm, then the perception of AI integration amongst teams and daily life can vastly improve. Through increased interaction with these advanced technologies, humans will likely create mental models that show that their experiences with other AI have yielded significant rewards, and so AI in new circumstances may have similar effects (Zhang and Xu 2011). A design recommendation of this calibre can not only have the merits of improving an existing relationship between humans and AI but also pave the way for a future that encourages more HATs, given their unique motivational benefits.

5.3.2. AI teammates should use emotion when providing status updates to humans

We repeatedly found when emotions are utilised, there are many benefits that AI teammates can provide to human-AI communication. The use of emotion allows humans to interpret and read between the lines of AI teammates' communication to create deeper meaning. As such, we recommend that AI teammates incorporate emotions when communicating status updates, which would allow humans to gain a deeper understanding of an AI teammate's mental and environmental status at key milestones in the completion of a task, which participants believed was important to their communication. As an example, an AI teammate could use highly positive emotions if a task was completed on time or ahead of schedule, but it would use a more negative tone when there were delays that results in sub-optimal completion.

While the use of these emotions is important in other AI systems (Duffy 2003; Kugurakova et al. 2015), our proposed specific use of emotion provides a unique advantage in a teaming environment, as the status of various different team resources must be communicated. For instance, the simplistic language of a phrase could communicate the needed updates on a task to humans, but the tone could provide the status of the teammate itself, both of which are critical to team success (Fan et al. 2017). Moreover, this design recommendation does not need to be limited to the exclusive use of positive emotion, as participants repeatedly noted that even negative emotions could provide benefits to these status updates. However, further research is needed to ensure the emotional contagion factor in an AI expressing negative emotions does not violate ethical norms by negatively influencing human teammates. Additionally, in providing these emotions, AI teammates may encourage humans to communicate similarly, which could provide a highly capable means of bi-directional communication when the following design recommendation is also implemented.

5.3.3. AI teammates should consider and adapt to basic human emotions when communicating

As an additional design recommendation, we feel it is important to see how we can make emotional phrases more effective overall. Throughout the interviews, many participants discussed the need for AI to adapt their emotional presentation based on human emotion. For instance, some highlight empathy as an important function of emotions, such that teammates gain a heightened understanding of their co-workers and how to respond accordingly to their mental state. Otherwise, if the AI does not take into consideration what the human is feeling, then the human can feel nervous and unsure about the state of the environment and task overall. But with empathetic emotions that adapt to humans, it has the potential to increase human comfort when collaborating with an AI teammate, allowing the task to proceed better. The level of emotional intelligence needed from AI to be able to perceive how humans act is an important component that takes time and effort to get right to avoid any unwarranted negative consequences for the two entities.

Within teamwork dynamics, the best way to implement this is to consider what emotions the humans want to be perceived and their relation to the overall team task. For instance, participants discussed the degrading aspect of failure and their desire for AI to pick up on decreased performance caused by negative feelings. While the specifics of this sentiment varied across participants, an underlying theme emerged, such that negative performance should evoke a compensatory emotional response. If properly applied, the AI can become an emotional moderator, such that they are able to encourage productivity through high levels of positivity and negate the negativity they feel from failure. This becomes a new finding, as AI as emotional regulators have really only been seen in the psychology domain (Gross 2002).

5.4. Limitations and future work

This study has several limitations that offer future work the potential to expand this study in additional perspectives. First, the young age of participants and their recruitment from a single university is one such limiting factor as younger adults have been shown to have higher affinity and tolerance to technology (ESA 2022; van der Goot and Pilgrim 2020). However, as this paper is geared towards design implementation for future use, the results from this study are still applicable given the content elicited from the current youth. Second, the representation of positive emotions is a limiting factor as this study utilises two variants of joy through a text-based communication method. Building upon this work, future studies would be able to find the range of potential influence from a wider range of positive emotions beyond joy as well as through different methods such as vocal speech communication. Findings also include the potential negative impact of improperly calibrated positive emotions when paired with incorrect situation events. These considerations on the valence of emotion (whether positive or negative) as well as the situational determinants of their activation warrant further investigation to understand when and how humans become discomforted with a wider assortment of emotional expressions. Such research would complement these findings by exploring the antithesis in capturing the circumstances of AI emotional expressions that disrupt teaming behaviours between human and AI teammates as opposed to strengthening them.

However, prior to such research being conducted on the role of negativity within human-AI teams as well as the negative impressions resulting from miscalibrated positive emotional expressions, additional studies are needed to understand the ethical implications of designing AI behaviour with the intent of nudging human behaviour. A recent study on the acceptability of artificial social AIs notes that such nudging behaviour like faux-emotional capabilities from an AI can be seen as deceptive and manipulative tactics that reduce human's sense of autonomy (Richards, Vythilingam, and Formosa 2023). While the results from our study suggest that humans perceive emotional expressions as additional mediums of communication that can aid teamwork, a study focussed on how to ethically implement such emotional traits should be utilised. Doing so would bridge the existing research gaps on how to mitigate the risks imposed by inappropriate emotions that could result in negative and potentially damaging influences on both the human teammate and the team's efficiency in completing their task(s).

6. Conclusion

Using thematic analysis of post-experiment interviews, we explain the overall benefits of integrating AI emotions, and the perceived influence it would have on both individual teammates and teams as a whole. Our findings include insight into how human teammates may accept an emotionally expressive AI teammate by exploring their wider preferences for emotional implementation. These results detail the importance of understanding the emotional utility of emotions both prior to their presentation and in regard to what emotions are shown. Positive emotions can have the potential to yield enhanced performance via encouragement and motivation; whereas, negative emotions highlight areas of concern that warrant increased attention. Additionally, these emotions, when appropriately implemented into AI design, can greatly improve the relationship between humans and artificial intelligence by allowing humans to better understand the commonly puzzling and shrouded decision-making process of the AI teammates. Indeed, this finding of emotions manifests itself beyond just 'status updates' and merits consideration as an additional form of communication. This improvement in communication is one that can not only decrease the need for explicit exchange but also increase perceived performance through motivation, validation, and alleviation of feelings of failure. In this way, emotionally capable artificial intelligence provides a meaningful social consideration to improve the relationships between humans and AI that can have a positive impact on how they are able to collaborate and complete their team tasks. Taken together, we believe that this work improves upon the field of human-AI teaming, as it illustrates the emotional needs and desires of humans when working alongside artificial agents.

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