Role-Based Perceptions of Computer Participants in Human-Computer Co-Creativity

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Abstract. The purpose of this ongoing research is to better understand the potential contributions that computers can play in situations where people interact with computers towards creative pursuits and goals. Past research has provided sets of definitions of different roles that a computer plays in human-computer creative collaboration. Thus far, we look into the advantages and limitations of having such roles. In particular, this paper contributes an analysis and categorisation of the coverage of existing role classifications for computational participants in co-creativity. This analysis is complemented by a comparative review of the use of roles to understand and structure creative collaboration between people only (i.e. without any computational participants involved). Our wider project investigates whether these defined sets of roles are a. adequate and b. helpful for understanding the perception of computational contributions in co-creativity, with a study planned to investigate the roles of current systems in practice. This project considers both co-creative computer systems that currently exist, and systems that could potentially exist in the future. Our goal is to reach a point where the perception of what is possible in human-computer co-creative collaboration is enabled and boosted (but not constrained) by a definitive set of roles.

1 INTRODUCTION

Computers are taking on more creative tasks in collaboration with humans. *Human-computer co-creativity* is a field which looks at the collaboration of computers with humans and other computers on a creative task. Such co-creative computer systems can contribute in an impressive array of different creative scenarios, from drawing to poetry (see e.g. [4] or [12]).

Alongside these practical achievements, we are developing a better theoretical understanding of how computers can contribute to co-creative scenarios. More specifically we ask, what roles can/do computers take, when collaborating with humans in interactive creative scenarios? This is an important route towards understanding the (actual) current contributions and limitations of co-creative systems, as well as in examining possible biases that humans may have in designing, implementing and evaluating different co-creative scenarios and the extent of collaboration in different scenarios [11].

'People do have a tendency to discount and even dislike computer creativity' [21, p.6]. Moffat and Kelly examined reactions to music composed by a computer system, and found that some musicians displayed (often subconscious) discrimination, reacting negatively to computer composed music. Similar biases arose (though not at a significant level) in Pasquier et al.'s experiments ten years later [26] and in the evaluation experiments in [10].

A reasonable concern is that the possible biases being introduced by human evaluators (and designers) are imposing additional limitations on co-creative systems; perhaps perceptions of what computers can (or cannot) do are influencing what we attempt with co-creative systems that interact with people. This is the issue we investigate in this project. Are our existing computational role classifications affected by general perceptions of what computational creativity capabilities, and if so, does this mean existing classifications are inadequate, over restrictive or limiting?

It is useful at this point to define some more key terms that we use during this paper. *Collaboration* is defined by [28] as: "a process in which two or more agents work together to achieve shared goals."

We define, in this paper, that a *role* is an assignation of specified responsibilities and behaviours that an agent plays in a collaboration. Roles can be emergent or pre-defined. In this paper we focus on pre-defined roles, as current computer roles are typically dictated in advance when building use-cases, and the analysis of emergent roles for the computer would require more data on long-term human-computer co-creative collaborations, which are scarce.[3]

Several role classifications exist for humans and computers collaborating in co-creative scenarios. We collate and analyse these below. Our concern is whether the coverage of existing role classification schemes is adequate and appropriate for describing and analysing the space of possibilities for computers and humans to collaborate co-creatively. An early example given by [31], describes how a computer can make strong contributions to co-creative scenarios through the ability to perform repetitive tasks accurately and rapidly to assist the creativity of the human participant(s). Their stated focus is on "the degree to which a PCG algorithm which generates valuable and novel content for the human designer to consider can contribute to human creativity." [31, p. 4]. This is indeed one useful type of role that computers can play in creative scenarios. A notable concern, however, is whether computer roles in such schemes overly focus on enabling creativity by the human participant(s), relegating the creative capacity of the computational agent(s) to that of a supporting role rather than as creative contributors in their own right.

What might we gain from more evenly balancing the creative responsibilities in human-computer co-creativity? Burleson [3] posits the potential benefits for a hybrid human-computer system, in that it could positively contribute to the creativity overall, and that of both the human and computer participants. A similar approach is also taken in more recent mixed-initiative creative interfaces (MICI) research (e.g. the MICI workshop at CHI 2017, where many papers "give the computer the status of creative agency and initiative thanks to AI"[6, p. 629]). As reported below, Kantosalo and Toivonen [13]

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[3] A new role for a computational system could emerge over time, for example, if it is used for a purpose it was not originally designed for.

have taken some steps towards modelling computational co-creative systems; our ongoing project moves beyond those steps to identify a set of roles for co-creativity with broader and more accurate, detailed coverage of the potential roles that a computer collaborator can take.

This paper's main contributions are: i) the analytical specification of the space of possibilities we get from existing human-computer co-creativity role classifications, and ii) the comparative analysis of these role classifications to the use of roles in human-human co-creativity scenarios.

This paper contributes to an ongoing wider project. Our project research question asks whether existing roles categorisations are sufficient for covering the entire space of possible roles that is possible with computational partners. We consider both co-creative computer systems that currently exist, and systems that could potentially exist in the future. Do the roles that we have in the current literature categorise the whole space of co-creative possibilities? Or, do they just cover what we have at the moment - or do they not even cover what we have at the moment?

This paper represents completion of the first stage of this work in progress; setting the theoretical foundations in place, so we can continue onto planned studies to evaluate existing roles in practice in current co-creativity systems. This will allow us to experimentally evaluate the coverage of existing roles, identify gaps in the coverage, and explicitly specify possibilities for new roles that are not yet considered in the literature.

Our goal is to reach a point where the perception of what is possible in human-computer co-creative collaboration is enabled and maximised (but not constrained) by a definitive set of roles useful for designing and analysing co-creative systems.

2 ROLE CLASSIFICATIONS IN HUMAN-COMPUTER CO-CREATIVITY

Possible roles for computers in the creative process have been presented in creativity support tool literature and more recently in computational creativity literature. We start by reviewing early role categorisations from creativity support tool literature and then consider more recent categorisations from literature focused on human-computer co-creativity.

We have listed the different roles and their origins in table 1, which also shows some overarching themes or categories between different role categorisations; we contribute these overarching themes as an output of our comparative analysis.

The rows are ordered by date (from oldest work to newest, moving from left to right), and the columns are ordered according to the autonomy and responsibility afforded to the creative agents (from least to most, as we move down the rows). It is interesting to note that as we move through time, from 2005 onwards, there is an increase in the maximum amount of creative responsibilities covered by roles in the classifications. In other words, over time, there is a general trend towards allowing computational participants increasingly more complex and more autonomous roles.

2.1 Supporting roles for computers in creative contexts

Many of the earlier role classifications for human-computer co-creativity focus on distinct supportive roles. This suggests the importance of support roles for creative collaboration.

Perhaps the most well cited description of possible roles for computers in the creative process comes from Lubart's 2005 [16] introduction to the special issue of Computers in Human behaviour. He considers four distinct roles for the computer; The *Nanny*, which is a supportive role, encouraging the creativity of an individual human; The *Pen-Pal*, which is also a supportive role focused on facilitating communication between creative partners; The *Coach*, which considers increasing the human's creative capability through teaching, and finally; The *Colleague*, a computer which is able to aid a human by contributing new ideas. This classification is very much oriented to creativity support rather than active participation in the creative process. Only the last category, Colleague, allows for an active contribution from the computer.

Another classification of roles focused on the support for creativity rather than co-creativity comes from Nakakoji [24]. It includes three roles: The *Running shoe*, which focuses on supporting faster creation; the *Dumbbell*, which focuses on training human creative capacity; and the *Skis*, which describe the role of systems enabling completely new ways of creating, such as new instruments for musicians. These roles echo the two themes support and training in Lubart's classification and introduce a third, new category focused on enabling human creative behaviour.

The first role categorisation originating from computational creativity literature is by Maher [17]. It is still very much focused on the supportive roles a computer can have in the creative process, giving categories of *Support* and *Enhance*, which deal with providing tools and techniques for creativity or enhancing the creative capabilities of the human by encouraging creative cognition. Like Lubart, Maher, whose categorisation stems from the practical classification of interactive computationally creative systems, considers a more active role, the role of a *generator*, for the computer.

Some supportive roles are also echoed by Negrete-Yankelevich and Morales-Zaragoza [25], who note that in addition to being active participants in creative collaboration, computers can also support creativity by providing the general *environment* or *toolkits* for the creative humans.

From these suggested supportive roles we have derived three possible overarching categories for computer support: a general support role focused on traditional productivity aspects such as facilitating faster creation, a training role focused on teaching or training creative ability, or an enabling role focused on allowing for new[4] forms of creativity.

2.2 Participatory roles for computers in creative contexts

The role of providing new materials for the human to work on by generating new creative artefacts or parts of them is visible in many roles suggested for computers in the co-creative process, including not only Lubart's [16] and Maher's [17] classification, but also the classifications of Negrete-Yankelevich and Morales-Zaragoza [25], Kantosalo and Toivonen [14], and Hoffman [8]. But the generate-role is but one way in which a computer can be an active part in creative collaboration. In addition we have identified roles dealing with the evaluation of creative artefacts, problem finding, and ways to control the initiative in creative collaboration.

Some categorisations such as the categorisation by Kantosalo and Toivonen [14] give distinct roles for concept generation, evaluation and definition, but for example Negrete-Yankelevich and Morales-Zaragoza [25] have given a role definition, in which the roles are

[4] By 'new forms of creativity' we include both P-creativity (new for the creator) and H-creativity (completely new) [2].

	CATEGORISATIONS [this paper]	Lubart, 2005 [16]	Nakakoji, 2006 [24]	Maher, 2012 [17]	Negrete-Yankelevich & Morales-Zaragoza, 2014 [25]	Kantosalo & Toivonen, 2016 [14]	Guckelsberger et al., 2016 [7]	Hoffman, 2016 [8]
Creativity Support Tools	SUPPORT	Nanny	Running shoe	Support	Environment			
		Pen - Pal			Toolkit			
	TRAIN	Coach	Dumbbell					
	ENABLE		Skis	Enhance				
Co-Creative Colleagues	GENERATE	Colleague		Generator	Generator	Generator		Divergent agent
					Apprentice			
	EVALUATE					Evaluator		Convergent agent
					Master			
	FIND PROBLEMS					Concept definer		Divergent agent
	CONTROL INITIATIVE					Pleasing Agent	Supportive Agent	
						Provoking Agent	Antagonistic Agent	

Table 1. Roles for computers in the creative process, including overarching categories that our analysis has produced.

additive, describing increasing capabilities of the computational collaborator: A generator can only generate, whereas an apprentice is also able to evaluate its output, and a master can also decide what to create to some extent. Likewise Hoffman's [8] categories of divergent and convergent agents stemming from the theory of divergent and convergent thinking are roles that do not deal with just a specific task or ability.

Finally, in addition to the ability to participate in specific tasks required by the roles of generate, evaluate and find problems, there are roles that better fit a behavioural strategy selected by the computer in human-computer co-creation. Both Kantosalo and Toivonen [14] and Guckelsberger et al. [7] have suggested that the computer could try to actively satisfy their human collaborators needs by assuming a pleasing or supportive role, or more actively challenge the human or focus on its own goals by assuming a provoking or antagonistic role.

In addition to the roles presented here there are many domain specific roles that have not been discussed in this paper as they are not generally applicable.

3 ROLE CLASSIFICATIONS IN HUMAN-HUMAN CO-CREATIVITY

Having defined the space of possibilities covered in existing role classifications for human-computer co-creativity, we turn our attention to role classifications in human-human co-creativity. As part of this paper's contribution, we will now consider the use of role classifications for scenarios where people collaborate with other people in creative tasks.

We are familiar with the concept of assigning roles to people working in teams or other collaborative scenarios. Arguably the most well-known examples of sets of roles that humans take (consciously or unconsciously) in collaborative scenarios are the Belbin team roles for collaboration [1]:

- *Plant* - idea generators, innovators
- *Resource Investigator* - networkers, creating opportunities
- *Co-ordinator* - organising people and focusing on the bigger picture
- *Shaper* - task-focused achievers
- *Monitor Evaluator* - critical observers
- *Teamworker* - those who maintain or fix group relations
- *Implementer* - those who put plans into action
- *Completer Finisher* - getting things done as well as possible
- *Specialist* - experts in an area of knowledge

While there is scope for creative results to be achieved using teams organised around Belbin's roles, arguably the only role with direct creative responsibilities is the *Plant* role. Our interests here lie more in teams comprised of creative individuals (human and computational).

Edward de Bono proposed a theory around different thinking styles which could be applied to our goal of roles in creative collaboration. The six distinct thinking styles identified by de Bono are represented as different coloured *Thinking Hats* [5]:

- Blue hat thinking - process
- Red hat thinking - feelings
- White hat thinking - facts
- Yellow hat thinking - benefits
- Black hat thinking - cautions
- Green hat thinking - creativity

These 'hats' could be relevant as different roles for co-creative participants, as de Bono considered their application to complex problem solving, which is often seen as an arena for creativity; de Bono argued that people could wear different hats to approach about a problem in different ways (though an individual person can swap between hats as needed). There is less focus on how different hats interact in collaboration, which is something we wish to uncover in our roles. Also, we have a similar issue to the Belbin team roles, in that only the Green hat is specifically associated with being creative.

Bringing us closer to the remit of human-computer co-creativity, Mamykina, Candy and Edmonds [18] talk about support for human-human co-creativity in the context of an artist working with a technologist. They found several different models for co-creativity: *assistant model*, *full partnership* and *partnership with artist control*. The models differ in terms of who does what, so the choice of model depends on what tasks an artist and technologist assume during collaboration (with the possible tasks being: *creative concept*, *construction* and *evaluation*). In the assistant model, the artist is responsible for the creative conceptualisation (initial idea) and evaluation, with the technologist responsible for the construction. In the full partnership model, both do all tasks, and in the model of partnership with artist control, both do concept creation and construction, but only the artist evaluates. Note that the artist is always afforded responsibilities for creative conceptualisation and evaluation, but not always for construction. Similarly, the technologist is always afforded responsibilities for construction, but is restricted in most models from evaluative responsibilities and in one model from creative conceptualisation. The roles, tasks and resulting models are interesting in terms of understanding different scenarios that might be encountered in human-computer co-creativity, but the work in [18] does not necessarily bring us any closer to identifying different types of roles beyond 'artist' and 'technologist'. What types of participant comprise a creative team?

Modelling the composition of a group in team-based creativity is discussed by Reiter-Palmon, Wigert and de Veerde [27], who review various comparisons between heterogenous teams (with participants of various types) and homogenous teams (with participants similar in type). Observations arise on on the usefulness of 'functional diversity' (i.e. participants offering different functionality to the team), however no detail is given on what actual functions might be useful to include.

West [30] proposes a theory of creativity in work groups that includes investigation of team diversity along three other factors: task, team integration and external demands. In his work it is apparent how roles are very important for social systems, but they are seen more as a fact arising from occupational constraints and responsibilities rather than roles established for the creative activity itself.

Mumford, Whetzel and Reiter-Palmon [23] make similar observations on roles arising from occupational requirements, although they are looking at organisational creativity (specifically, the emergence of creativity in organisations over time), as opposed to creative collaboration per se. Mumford et al. include a thorough definition for roles in organisations, and describe how roles relate to creative problem solving: "Role requirements and role characteristics are not defined in an arbitrary fashion. Instead, role requirements and role characteristics emerge, in part, as a function of the issues confronting the organization." In other words, roles emerge relevant to the scenario rather than being defined independently of the scenario being tackled. Mumford et al. go on to say that "even when the requirements of a role call for creative thought, the nature and success of peoples' creative problem solving efforts may be conditioned by other characteristics of their roles." Hence participants in creative collaboration are not purely defined by their creative contributions, but by broader behaviours and motivations.

It has been argued that assigning predefined roles to participants actually *stifles* creativity [19]. This is a very important point for our purposes. Wang, Xhang and Martocchio [29] investigated the alternative of role *ambiguity* and its effects on creativity, hypothesising that too little or too much ambiguity in the definition of roles both limit creativity (but tolerance to such ambiguity is useful). They presented experimental evidence supporting this hypothesis, suggesting that moderately defined roles are important for human creativity in organisations. For our purposes, this suggests that defining roles for the human and the computer is important for the successful adoption or analysis of the co-creative system, but that a strict role classification may actually constrain creativity. Similar observations have been found in the study of how constraints affect computational creativity [20]; too many constraints or too few constraints had negative repercussions for the level of creativity exhibited by the system. Perhaps, in future work when we are evaluating existing role classification systems, useful parallels can be drawn between a. defined roles for creative participants and b. defined constraints that creative participants must work under?

In summary: we do see examples of specific roles being assigned to people participating together in team work, such as Belbin's team roles [1] or de Bono's thinking hats [5]; however these often restrict the creativity to being part of only one participating role (or hat), rather than creative contributions coming from multiple participating roles. Mamykina et al. [18] hint at a similar restriction of creative responsibilities in their thoughts on artist-technologist collaborations. Team heterogeneity can be achieved by introducing different roles, with positive effects on creativity [27, 30]. Mumford et al. [23] advocate allowing a more fluid set of roles to emerge over time. Imposing overspecified predefined roles may, however, overly constrain the creative potential of the team [19, 29].

Having reviewed the use and applicability of roles in creative collaborations with people, we can now use this knowledge to recontextualise and reconsider the existing role classification systems for human-computer co-creativity. We do this by examining parallels that can be drawn between human-computer and human-human co-creativity roles, in the next section. Then we discuss more generally what information we gain for our understanding of computational participants' roles in co-creativity.

4 DISCUSSION

We now have a clearer specification of the existing role classification systems for human-computer co-creativity, and knowledge about the use of roles in human-human co-creative scenarios. What information do we gain from comparing this knowledge, about the perceived and actual range of possibilities for computational contributions in human-computer co-creativity?

4.1 Parallels between human-computer and human-human co-creativity roles

In both human-computer and human-human co-creativity role classifications we see classifications that focus on more task-based roles, e.g. [16, 25, 17] and [18] respectively; we also see classifications oriented towards including more complex behaviours e.g. [8, 14, 7] and [5, 1] respectively.

There are similarities between Hoffman's [8] divergent and convergent thinker roles and de Bono's [5] thinking hats, which become strategies to drive divergent and convergent thinking. Both role classifications require the agent to adopt a specific stance to the problem at hand and deploy different ways of thinking.

There are also similarities between Mamykina et al.'s models [18] and Negrete-Yankelevich's and Morales-Zaragosa's [25] roles. Mamykina et al.'s assistant model corresponds with the computer participant taking a Generator role in Negrete-Yankelevich's and Morales-Zaragoza's terms (with the computational participant as technologist and human participant as artist); full partnership corresponds to the computer taking the master role (where human and computational participants could either be assigned as technologists or artists). The only model in [18] which does not fit quite so neatly with [25]'s roles is the partnership with artist control model, which falls in between the Apprentice and the Master roles for the computer.

Overall, there are parallels between the distinct models proposed by Mamykina et al. and some of the overarching divisions that we have identified from comparing various human-computer collaborative roles: specifically, the *Generate*, *Evaluate* and *Find problems* divisions.

It is naturally easier to equate the artist in [18] to the human participant, and the technologist to the computational participant. But if the reverse assignment was considered (the artist is the computational participant, the technologist is the human participant), then the Mamykina et al. models help open up thinking about the possibilities of more diverse roles for computational participants in co-creativity. Currently, for example, there is no role in the classifications reported above in which a computer participant outsources generation but retains evaluative control and problem definition on its own. This is in part captured by the model by Kantosalo and Toivonen [14], which suggests that in task-divided co-creativity creative responsibilities can be divided in this way, however for this the specific roles in the model have to be considered as additive roles.

Although the Belbin [1] team roles are more for general team collaboration instead of specifically co-creative collaboration, it is interesting to attempt to draw parallels between the Belbin roles and the categorisations that have emerged in our comparative analysis of human-computer co-creativity roles. Some possibilities have been mapped below:

- Plant → FIND PROBLEMS
- Resource investigator → ENABLE
- Co-ordinator → SUPPORT; CONTROL INITIATIVE
- Shaper → GENERATE
- Monitor evaluator → TRAIN; EVALUATE
- Teamworker → SUPPORT; TRAIN; ENABLE
- Implementer → GENERATE; CONTROL INITIATIVE
- Completer Finisher → GENERATE; EVALUATE; CONTROL INITIATIVE
- Specialist → ALL [depending on how they use their knowledge]

As shown above the Belbin [1] roles can be mapped into several categories in our analysis. This suggests that the Belbin roles are more nuanced than the typical roles assigned in human-computer co-creativity to computational collaborators. Computers can of course act in multiple roles simultaneously, but it is worth considering if our categorisations should name some of these unique combinations, producing something more similar to Belbin. This type of thinking is already somewhat present in the additive roles by Negrete-Yankelevich and Morales-Zaragoza [25].

Current human-computer co-creativity roles have little variety in terms of the 'control initative' roles, such as leadership[5], which seem to emerge in Mamykina et al.'s [18] roles, as well as in Belbin's [1] team roles. This moves us towards considering differences between human-human and human-computer co-creativity roles.

4.2 Differences between human-computer and human-human co-creativity roles

No standard role classification system has emerged from our review of human creative collaboration. A reoccurring observation is that over-prescriptive or overly general role characterisations perhaps stifle rather than support creativity. This is a very important point for our purposes. Perhaps our attempts to categorise role classifications are misguided and unnecessary?

We note, however, that having no accepted standard role classification system at present does not result in the situation where computers are given free rein in co-creative scenarios. As discussed above, a computer's role in co-creativity is often limited by perceptions.

By failing to identify roles that we currently have and roles that we could have in the future, we are standing still. We would fail to have this analytical tool that we could use to better understand relationships between human and computational participants.

Hence we continue to pursue the use of roles as a model; this becomes a tool to analyse and better understand human-computer co-creative applications and potential. It also helps us to map the potential contributions that computers can make in co-creative scenarios, and identify areas that are under-explored, unlocking the potential of future research.

The ideal scenario would be to arrive at a point where perception-based limitations are no longer an issue, and hence the roles that we investigate are no longer needed. Until we reach that point, though, we argue that a more comprehensive role classification helps justify and positively emphasise the capabilities and potential contributions of co-creative computational systems.

5 FUTURE WORK AND EVALUATION

The existing role classifications that we have for human-computer co-creativity are theoretical, in the sense that they have not been experimentally verified. They are essentially hypothetical labels, assigned rather than analysed. In future work we will evaluate the current role classifications as they are manifested in practice, which will help us to identify gaps and coverage of the existing classifications.

We plan to gather evidence through a study with computational creativity / human-computer interaction researchers. The participants will be given several scenarios describing use-cases of co-creative systems. The participants will also be given a list of possible roles for participants in the co-creative scenarios, accompanied by brief descriptions of each role. These roles will be drawn from the above reviewed literature. Each participant will be given each scenario one

[5] The role of leaders is according to [22] typically seen as passive, guiding, but they suggest the leader is in fact an active collaborator.

by one, in randomized order, and they will be asked to rate how strongly each of the possible roles describe each of the collaborators indicated in the current scenario. In addition, the participant may suggest possible new roles in an open field.

We note two points that are particularly important to control for.

1. Firstly, the creativity of the scenario itself is an important question to ensure the scenario falls within the co-creative space (i.e. the creative domain in question may play a role in people's perceptions of what is creative, for example someone may think painting a picture is more creative than writing computer software – or vice. versa). Hence participants will be divided into two groups; the included scenarios will either be presented in domain-independent language (group 1), or will cover multiple creative domains representative of current computational creativity research, as guided by the mapping of research in [15] (e.g. musical creativity, linguistic creativity, etc) (group 2).
2. Computer creativity can be a controversial question to consider. This issue must be acknowledged in this work, as in any computational creativity research, but detailed investigation is beyond the scope of this work. There are numerous works looking into this question e.g. [9]; to control for this concern, we specifically target participants who are familiar with computational creativity research, and we will write the scenarios in neutral language such that it is not stated which is the computational partner and which is the human partner. Participants in the study will be made aware, for full disclosure, that they are evaluating scenarios which describe examples of human-computer co-creativity.

If we gather sufficient evidence that existing roles offer inadequate coverage of the space of possibilities for computers in co-creative scenarios, our research will then develop new theoretical models of computational roles, informed by our participants' comments. This model is intended to influence the ways people working in this field operate in future, by broadening perception of what computers can be capable of in co-creativity. We also hope to validate the theory in practise by observing human-human and human-computer pairs working on the same tasks.

6 CONCLUSIONS

In this paper, we outlined and categorised the space of co-creative possibilities covered by the current sets of roles in the literature. We looked for inspiration from reviewing how role classification schemes are used to understand and analyse creative collaboration between people, and we reflected on implications from this review.

Role classifications in co-creativity have appeared over recent years and have increasingly afforded computational co-creativity participants with more creative agency and more varied responsibilities. We seem to be moving towards a less limited set of views on what computational participants can do, though we are not yet at a point where computational participants are given the same agency as human participants.

In introducing extra roles to support the perception of computers in a wider range of creative behaviours, our end goal actually is to reach a point that human-human collaborative creativity is at, i.e. where predefined generally applicable roles are no longer necessary at all. This seems somewhat contradictory; however we argue that roles have emerged as an important analytical tool to study the potential of computational partners in collaborative creativity. Roles can also act as prompts to identify and highlight underexplored possibilities: becoming stepping stones towards more creativity potential.

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