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Art & Science Collaboration:
An Exercise in Conflict Transformation

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Abstract

The authors explore the nature of art-science collaborations from a conflict theory perspective. They suggest that the traditional study of these collaborative forums has focused on the assumption that collaboration will necessarily achieve a common good through consensus and appreciation of shared goals. This research is based on two parallel efforts: The first was a series of roundtables that provided a safe space for artists and scientists to talk about the relationships between their fields. The second was an artist-led series of collaborations to advance public science literacy. The roundtables offered a unique opportunity for members to have sustained, facilitated interaction, a near impossibility in their disciplinary silos and the deeply rooted public perception of the art-science dichotomy. This tension served as a catalyst for creating a new understanding of art-science collaborations, one that does not seek to compromise either but allows for the richness of each to be parallel paths to knowledge. Using the lens of conflict transformation theory and an example of a successful art-science collaboration, the authors describe how a facilitated process leverages tension for deeper inquiry, and results in both product and process outcomes that still fully belong within each domain.

Introduction

In this study, we explored: "*How can art and science as distinct epistemological paths to knowledge, when considered together, create productive tension without threatening the integrity of either intellectual pursuit?"* We did so to challenge the prevailing notions of what is productive in art-science collaboration. We pursued our question through a post-hoc examination of (1) recorded dialogues between artists and scientists, and (2) interviews with artists commissioned to produce works that promote science literacy. We framed the work through the lens of conflict transformation theory. For purposes of this research, we define art broadly as the creative representation of the human experience; pursuits that span painting, sculpture, poetry, music, dance, and any other type of visual, performance, and language arts. We define science equally broadly as knowledge production based on a body of systematically arranged facts or truths that show the operation of general natural laws of the physical or material world, and are gained through observation and experimentation, including the social sciences.

We note that the data for this study was purposefully collected to support a different research endeavor. The original team – which includes all but the first author – had not imagined that theory related to conflict mediation or human rights would be present in the data until after we had completed the data collection and analysis of the earlier phase of the work. In critiquing the initial assessment, the lead author for this paper proposed that the data might offer new insights if it was reanalyzed through theory that informs peace, mediation, and reconciliation work. Adding this human rights researcher to our team, we revisited the existing data with a new theoretical model and produced the analysis reported here.

Background

For 60 years, art-science collaborations have helped to solve complex challenges with public understanding of science. Starting from a premise that art and science are "stereotypically thought to be at opposite ends of the intellectual spectrum," Wright and Linney (2006), two long-term art-science collaborators, point to the "legacy of blind faith in scientific fact, coupled with romantic notions about the subjective and imaginative qualities of art." The unfortunate – if widespread – perception of the two disciplines, at times promulgated by those within the field, is that they diverge on core epistemological questions, where art "is comfortable with uncertainty, and is not necessarily interested in finding answers; whereas much of science is looking for answers, and is - in some cases misguidedly - seeking certainty" (p.11).

Snow's (1959) now famous four-part Rede Lecture argued that this "polarization" of knowledge production led to impoverished thinking, and that the teaching disciplines needed to find a common ground for instructional design. Since then, a stream of studies have described bridges or integrated collaborative efforts (i.e. Ede, 2002; 2012; Miller, 2014) that characterize the benefits of synergy and mutual appreciation. Indeed, the National Science Foundation (NSF) in the U.S. has funded art-science engagement since at least the mid twentieth century, and The Wellcome Trust's Sciart program is well established. Born and Barry's (2010) synthesis of a rather large corpus of art-science collaborations, and their detailed review of an outlier project suggested that the majority of art-science enterprises

are framed as a public experiment in knowledge production. While their case study exemplified the hybrid space that is possible in a porous relationship between artists and scientists, they still conclude that art-science intersections remain subject to a definitional challenge. Despite this constant stream of inquiry, it remains unclear what beneficial outcomes flow from these investments.

Certainly, the vast number of project reports on funded art-science collaborations confirm that researchers and professionals recognize that career artists and scientists benefit from getting to know one another, finding common ground and finding inspiration in one another's work. As Fraser and Miss (2012) observed, when scientists seek out artists for visualizations, or when artists use a scientific concept to inform their art production, there seems to be a tendency for one form of knowledge production to establish the primacy of the interaction for their own purposes. That is to say, one uses the other instrumentally rather than a meeting of equals seeking a new transcendent path to knowledge production that meets the criteria for both disciplines. The premise for the research described in this paper is that many so-called collaborations have not moved the conversation beyond the artist as illustrator for science, and the scientist as content provider for the artist.

We note, that one precedent for the work report here was an international initiative jointly funded by the NSF and the Arts and Humanities Research Council in the U.K., A*rt-Science: Collaborations, Bodies and Environments*, goes beyond the knowledge production model to investigate questions of institutional, political, epistemic and technological conditions that underpin successful art-science collaboration (Dixon & Marston, n.d.). Other work has identified variables that may support deeper art-science collaboration. In their work, Wright and Linney (2006) found that using a common language, being creative, taking risks, and having public endorsement are important to successfully collaborate across disciplines. Despite these findings, there remains a dearth of documentation on the impact of these factors leaving much to be discovered about how to structure a truly successful interdisciplinary effort.

Some of our team members' prior work with artist/scientist collaborations encountered obstacles that tend to be unreported in final work. As we deliberated on the discordances in the literature noted above, there seemed to be an omission in characterizing the psychological dimensions of engaging in interdisciplinary or transdisciplinary work. We suggest that the majority of art-science collaboration reported in recent years can be categorized as hopeful collaboration where the spirit of goodwill and charitable accommodation may have concealed epistemological rifts. The final products of these collaborations demonstrate achievement of self-defined goals, but also seem to report process results with a blindly optimistic spin. It seems that reports of successful collaborations might succumb to the inherent challenges of the desire to avoid conflict that are clearly articulated by the social sciences (Tjosvold & Sun, 2002; Ulbig & Funk, 1999). The fact that reports are moot on conflict and tension may flow from the desire to appease funders, or a willingness to limit risk by members of the participating disciplines.

The Present Study

The data corpus analyzed in this study was a by-product of a larger NSF-funded initiative entitled Indianapolis: City as a Living Laboratory (I/CaLL). That initiative brought

together scientists, artists, and community organizers in 2012 to explore the impact of informal art-science experiences in Indianapolis, Indiana, a mid-sized US city, is fairly representative of the many cultures that comprise the US population. The city is known for its substantial investments in public art, is home to two nationally renowned art museums, a children's museum whose attendance statistics far exceed any other of its type in the country, and a strong scientific community.

As a city-wide collaborative effort, I/CaLL allowed for an in-depth exploration of how different public art mediums can serve as conduits for informal science learning at a city-wide scale. The project used public sculpture, poetry, music and dance as learning provocations for science literacy. Works were specifically created to address environmental science issues relevant to the oft-neglected waterways and underserved neighboring communities in five locations in Indianapolis. The music and poetry were commissioned in 2013 through a curatorial process to select artists producing original work (music) or compiling both non-original and original work (poetry). The selected musicians and poets also had to have prior experience interpreting place and an interest in environmental and science topics. The choreographers worked with a large dance company to develop and perform a series of place-based pieces.

The project team was led by three environmental scientists; one a psychologist/environmental scientist (an author of this paper) who lead the social science research component, an urban ecologist/professor of biology, and an earth scientist and director of a center for urban health. The project also partnered with a non-profit coordinating entity engaging fifty-five organizations working on river health restoration. Staff from these organizations were a resource available to the artists. The project also partnered with a community organizer who worked with the artists to identify scientists for technical support as they pursued their work. The project, as designed, conferred the authority on artists to select, engage and query scientists for the development of their work. It did so to avoid the presumption of instrumentality that was described by Fraser and Miss (2012) as a core limitation of prior science-organization funded collaborations where the scientists sought to use artists instrumentally. Some artists also pursued their own inquiry into river ecology themes that were the inspiration for the project based on a scientific briefing publication created for their use (Danoff-Burg, 2016).

Seven of the artists included in this study were based in the state where the work was displayed or performed (Indiana), three were based in New York City, one in Los Angeles, and one in Seattle, and one was a U.S. artist working in Switzerland. By the project's end in 2017, five sculptures had been installed, a series of poems were collected and written for each site, six original musical pieces were recorded and published online, and two dance movement pieces choreographed and performed. The authors of this paper conducted process interviews to document decisions and interactions with science content, and working scientists formed a primary source of data for this post hoc analysis.

While the larger I/CaLL effort set the stage for exploring public experience, it also afforded researchers the impetus to convene working artists and scientists in the Indianapolis community to engage in an open dialogue about their practices and potential opportunities. The art-science roundtables sought primarily to explore the production of knowledge. While the project scientists and artists funded to work on the project were

invited to attend a few of these dialogues, the attendees were primarily from the local community. Participants were invited to join brown-bag lunch dialogues to explore possible intersections with their own work pursuits. They received no compensation for participation. While some participants attended more than one dialogue, the non-profit art-science organization sought to broaden participation at each meeting by inviting new artists and scientists from the community to join for a discussion.

The roundtables were facilitated as a monthly series of exploratory discussions for artists and scientists to talk about the culture of their two fields, how they might collaborate more meaningfully, and how collaborations intersect with public understanding of science. The roundtables began with the basic assumption that discussion between the artists and scientists had the potential to create new knowledge and ideas of interest to the participants and eventually to the public. Critical to the roundtable discussions was the facilitator, who had experience working in the arts, had contributed to scientific work, and developed science education strategies for informal learning settings. The facilitator served as an interpreter/moderator helping to focus group conversations and encouraging participants to navigate conflicts. We use the word “interpreter” instead of mediator to signify that the group leader did not establish a neutral position, or seek to create a shared idea. The facilitator's goal was to help guide participants toward specificity that was true to their discipline, but could also help clarify for all involved, the understanding of that discipline’s knowledge horizon. Transcripts made from recordings of these dialogues formed the second category of content in our data corpus.

A final data source came from Riverrun Revisited, a site-specific dance performance choreographed by Butler University Dance Professor Cynthia Pratt and performed by dancers from the Butler Ballet. Riverrun Revisited, held at Brookside Park in Indianapolis on September 24, 2016, addressed scientific concepts and concerns about human intervention in the waterways in Indianapolis. The dance work was augmented with audio narrative clips pre-recorded by an informal science educator. We include Riverrun Revisited as an example of an art-science collaboration that illustrates the benefits of productive tension between the two disciplines. Interviews with the artists and scientists involved in the performance, and audience intercept surveys immediately following the performance were included in our dataset.

Theoretical Lens

The “third space” of knowledge production

In this study, we describe the model of emergent production of knowledge in a “third space,” a term that Bhabha (1990) coined to express the physical, emotional, and intellectual hybrid space that allows for learning to occur. Bhabha’s third space speaks to the environment, including the emotional and intellectual space, which needs to be created in order for people to make meaning, gain understanding, and explore "third" ideas. Bhabha considers the third space to be a place where "meaning is constructed across the bar of difference and separation" (p. 210). This paradigm helped to lay the foundation for the roundtable dialogues and allowed for the neutral location and format to support physical, intellectual, and emotional safety.

We draw on Bhabha’s theory for this work because it offers a clear framework for roundtable participants to articulate their differences effectively while being able to live

within the limitations of embracing or understanding the “other” culture's symbols and language. Bhabha’s work reflects on the act of cultures to make icons and symbols that attempt to define the knowledge inherent in those cultures. In this case, the cultures we brought into this third space were the practice of art making and the practice of scientific research. Consistent with that theory, we also adopted Bhabha’s approach to the role of the moderator/interpreter (or educator in Bhabha’s framing) who would "translate" the two languages without the goal of universality used in many conflict resolution structures. With this third space approach, the moderator/interpreter maintained a premise that the production of an intersection of the art and science disciplines would never be a finished work. The understanding of art-science collaborations that will continue to emerge comes from a mutual willingness to remain engaged in the interpretive process.

Conflict’s “third side”

For those working in the field of conflict resolution (see Deutsch, Coleman & Marcus, 2006), conflict is merely a fixed starting point that initiates a particular trajectory of ensuing action. It is not inherently negative, but rather a natural and inevitable process that can be harnessed for good (Ury, 2000). Through our consideration of art-science collaboration in this study, we approached conflict as a malleable term and defined by its relationship to specific cultures (Avruch & Black, 1991; Kimmel, 2006), in this case the cultures of art and science professions. To re-examine the explanatory chain of evidence that emerged in this study, we employed Ury’s (2000) premise that conflict is often misinterpreted in analysis as negative or violent in ways that obstruct viewing a “third side” in a conflict. According to Ury, the third side is the community of people surrounding a conflict who, by choice, can provide a detached and safe perspective within which to understand the conflict. The third side is essentially a “container for creative contention” that redirects the conflictual relationship in a positive direction. In this case, we hypothesized that the roundtable discussions themselves became a third side for the art-science dialogue. We suggest this container enables the group to circumvent what would normally be an impasse in a product-based collaboration, and creates the conditions for exploring the conflict itself in greater detail. The third side is the end goal for an interpreter, not resolution of conflict but rather agreement about a direction in which the two cultures can collaborate.

Methods

Data Sources

The primary data corpus for this study as noted above is comprised of: 1) transcripts from art-science roundtable discussions; 2) meeting notes and interview transcripts with commissioned I/CaLL artists; and 3) observation notes, intercept surveys, and transcripts of reflective conversations related to Riverrun Revisited, a site-specific dance performance that was informed by the other two data sources. A secondary confirmatory dataset was derived from the discussion that followed a live presentation of initial findings to a group of roundtable participants.

Art-science roundtables

Roundtables were convened in a neutral meeting space not overtly characterized by either discipline. The facilitator aimed to recruit a group of 20 to 25 people for each meeting,

with equal representation of working artists and disciplinary scientists. Attendance was flexible, with some participants attending many meetings and others attending only one or two. Over time, new people were invited to join the process, so the group remained porous. In all, 47 roundtables were convened, with a total participant pool of 135 attendees. For this study, we selected recordings of five 1-hour discussions that were agreed upon jointly by the facilitator and researchers, who determined that these recordings best represented the range of dialogue types, topics, conditions, and participant demographics. Roundtable conversations took place between March 2014 and June 2015. On average, 15 people participated in each discussion selected for analysis.

Artist Meetings and Interviews

As part of their I/CaLL commissioned process, artists convened monthly group calls. A researcher attended these calls and took notes to stay abreast of how the artists engaged with each other and the science content. Five of the commissioned artists/curators involved in the I/CaLL initiative were also interviewed every other month between September 2014 and June 2015. These interviews were designed to provide insight into the artists' approaches to creating science-focused public artwork, and explore the process of collaborating with scientists. The transcripts of those interviews offered a critical view of processes that were product focused.

Riverrun Revisited Observations, Intercept Surveys, and Reflections

Two researchers were present to observe Riverrun Revisited, collect intercept surveys after the event, and conduct in-person reflection sessions with key collaborators involved in the project. Forty-five people responded to the retrospective pre-/post-event survey. All respondents were 18 years of age or older and currently living in Indianapolis. Most were longtime residents of the city, with 58% having lived there for at least 10 years. Reflection conversations were held with Cynthia Pratt, the choreographer of Riverrun Revisited; the science educator whose voice was included in the Riverrun Revisited audio track; a community organizer; and an urban ecologist. All were part of the greater I/CaLL team. Reflection conversations were informal explorations of the goals and intentions of *Riverrun Revisited* as it pertained to the goals of the I/CaLL project.

Secondary Dataset Used for Validity Testing

We presented an early draft of our findings to the roundtable participants using the framework of conflict transformation theory, to test the theory for validity. This event was convened in May 2017 as a public forum in Indianapolis and attended by 16 participants. All 16 had been to at least five prior roundtable conversations, 10 had been to 10 or more conversations, six members were at 15 or more previous roundtables, and two participants had been involved in over 20 events.

Analysis

To analyze roundtable conversations, we began with a series of open coding exercises, adhering closely to the language and statements made in the discussions. We then undertook an axial coding exercise to identify themes that emerged. In total, four researchers participated in the coding strategy of the roundtable discussions. At the conclusion of this effort, a fifth researcher with expertise in conflict theory critiqued the findings to date, and then developed a new explanatory theory for the evidence we had

assembled. It is that post-hoc critique that shifted understanding of the results that we will explore in this paper.

Qualitative data resulting from meetings and interviews with commissioned artists were transcribed and entered into an Excel file and coded to highlight the following themes:

• **Perceptions of Science** – views on science, including values and formative experiences with science or scientists;

• **Science Knowledge** – how the artists gathered information about science and used science resources, and their confidence in their own science knowledge; and

• **Intentions of Work** – what the artists hoped their work would accomplish, as well as foci of their work.

A second researcher checked the codes and summarized themes across the commissioned artist dataset.

For Riverrun Revisited quantitative survey data, we used the social science statistical software SPSS to conduct analyses, including descriptive statistics and frequencies to see whether respondents understood the science topics conveyed through the event. A paired samples t-test was conducted to compare the respondents' answers to questions about their relationship to the science topics before and after Riverrun Revisited. Riverrun observations and reflective conversations were not coded, but rather used to inform the process of theory-development concerning the nature of art-science collaboration.

We employed a constructivist grounded theory approach to our analysis for all qualitative data in the primary dataset. This approach is well established for developing theory that may then be appraised later for explanatory coherence (Charmaz, 2000; Glaser & Strauss, 1967; Haig, 2005; Strauss & Corbin, 1998). We felt constructivist grounded theory was appropriate because prior research has tended to start with the assumption of an existing common ground between the arts and the sciences, something we suspected may not accurately describe how two knowledge paths might converge. People may also be operating under the erroneous assumption that simply finding a common area of focus will necessarily unite distinct factions.

The convening to test validity of the primary findings was recorded, transcribed, and analyzed for themes that corresponded to, expanded upon, or diverged from initial results.

Findings: The Relationship between Artists and Scientists

Norms of Professionalism

The roundtable conversations brought together artists, scientists, interpreters, social science researchers, and community representatives to discuss topics of mutual interest and explore participants' perspectives. Both artists and scientists in these dialogues revealed that their disciplinary cultures share customary practices that have historically excluded the public. In the transcripts of roundtables and artist interviews, we characterized the implications of what practicing artists and scientists described in their work. For the purposes of this paper, we assume that participants from both disciplines follow rigorous methods that are accepted by their peers, and that they use evidence and seek to ensure

their work is accepted as valid among those peers. According to participants, artists are understood as relying on subjective representation through juxtaposition, ambiguity, or claims of fact, while scientists are seen as taking a systemic approach to acquiring knowledge based on objective observation, comparing data and identifying clear explanations for conditions in the natural world. Participants also identified the publicly held view of science as something that can produce reliably replicable theoretical models, though these models are always subject to refinement.

The two groups discussed common ground in their processes, considering compare and contrast as strategies for knowledge production. Though both artists and scientists agreed that they follow rigorous strategies for testing and experimenting with an idea, they typically described their work in radically divergent ways. Both groups claimed that their colleagues struggle to communicate or share their processes and results in ways that are accessible to people unfamiliar with their field. It would seem that the training artists and scientists experience includes the historical path to finding what constitutes truth in their discipline. This understanding of what constitutes a truth is really their path to knowledge production and results in unique destinations that may not be commonly understood by the general public. Moreover, the tension between these two separate destinations for their work may make collaboration more difficult if it is not acknowledged and wrestled with. As a team, we referred to these as competing knowledge horizons, ideas that may start with the same inspiration, but the process ends in completely different destinations.

We found that both groups were likely to draw on jargon-filled language. Both groups acknowledged that they generally lack training in how to share their disciplinary identities with the public. As one scientist explained to wide agreement among the artists and the scientists, "As we look at community, it's hard enough for scientists and artists to figure out each other's code, language, and culture. And it's really hard when we bring the public into this whole thing and say, 'how are you going to access this?'" Furthermore, the promotion and tenure process within academic institutions does not reward or promote non-academic publishing in the sciences. Both groups also acknowledged that their disciplinary cultures preserve a sense of elitism and self-segregation. We suggest that this is encouraged by each profession's structural framework, which fosters a need to demonstrate belongingness through gate-keeping. Most often the explanations for this desire to show disciplinary belongingness was characterized as the need to attract wealthy patrons or gallery representation among the artists, or as the proof of accomplishment within the academic system and scientific industries.

There was a distinct difference in how the artists and scientists approach content and employ pre-existing models common to their fields to describe their understanding of phenomena. Several artists mentioned that they intended to break with these precedent models, while scientists rarely echoed this sentiment. Scientists were more likely to describe the prescriptive path to knowledge accepted by the discipline as part of the authority they can rely on when making claims to a new truth.

Defining Art and Science Identities: Distinctions and Common Ground

Operational Considerations

The conversations revealed consistent ways of characterizing the self in the production of knowledge. A naturally occurring subject was the balance between (supposed) objectivity and creativity. Scientists, in particular, emphasized the importance of objectivity for those in their field, one noting, "If you're the only one who can experience it and measure it and have access to it...then it's not science." Artists echoed this concept when describing their perceptions of science, echoing a commonly heard refrain that the goal of the scientific method is to obtain objective results. A few scientists disagreed, suggesting that creativity plays an important role in scientific research, one saying, "You strive for the objectivity in the collection of data. The interpretation of the data, that's where the art is. That requires creative thinking and... the ability to perhaps see something in a way that people haven't thought about before."

The artists tended to be more effusive when describing the role of creativity in their work. Scientists thought that success stems as much from creativity as it does for artists, and paralleled their artistic peers in the idea that whimsy and play often led to breakthroughs and new exploratory directions. "It's as whimsical as an artist," said one scientist. "Basically, you are doing something in lab or you are researching something and all of a sudden you get a vision...[and] go down a new path where somebody else wouldn't have even thought to ask that question." Interestingly, many of the scientists did not ascribe to the use of the scientific method as a method of discovery and felt there is too much emphasis on it in science education.

Artists expressed the need to operate according to a patron's guidelines in order to have their projects funded. Scientists did not feel this tension in the same way. Although some scientists mentioned that it can be difficult to publish findings if the funder does not like the results, objectivity is central to the nature of science and as such a funding source should not interfere in the results of a scientific endeavor.

We note that this latter concept challenged questions of morality in art and science. While artists see themselves generally adhering to the bounds of propriety set by their patrons but possibly pushing those limits to express the truth of a phenomena, scientists see such transgressions as challenging the fundamental process of scientific inquiry or the ethical responsibility to maintain an objective distance from the subject matter at the heart of their studies.

Engaging the Public in Art and Science

Participants tended to have different perspectives about the goals and process of bringing their work to outside audiences. Artists were more likely than the scientists to value engaging the public. One artist said that, in publicizing her work, she hoped to inspire and intrigue a public audience; to give them a sense of what it took to produce the work of art. Scientists, on the other hand, emphasized the importance of publishing their work to advance scientific knowledge within their disciplinary community

Most participants, artist or scientists, however did not feel the same sense of urgency that their work advance public understanding. In one exception, scientists noted that public understanding was essential to securing funding, especially in relation to governmental grants.

Participants also shared the view that public engagement itself creates conflict. Scientists acknowledged the difficulty in making their research accessible and interesting to a lay audience. They particularly noted challenges with communicating how individual studies fit into the bigger picture without summarizing years of preceding scientific research. They were concerned that when the public lacks rudimentary understanding, science funding and ultimately science inquiry suffer. Artists echoed scientists' concern that the public often does not understand how a piece fits into the greater field. Yet artists seemed to feel less compelled to directly instruct the public or correct incomplete understandings of their work. One artist noted that if they explain their work in detail, they would not leave room for personal interpretation.

Understanding Conflict in the Context of Art-Science Dialogue

Conflict theorist William Ury (2000) argues that violence as a part of human nature is considered an "origin myth" in western society. Collectively, we have come to understand violence as an innate part of who we are, a fundamental belief about the nature of social interaction. Yet not all conflict is violent, and letting conflict harm or undermine a productive relationship is a choice.

In the case of the art-science roundtables, all participants pursued the end goal as a thought experiment, with no risk ascribed to failure. As a result, the conflict could be examined not as a violent juxtaposition of opinions vying to win, but rather free from the origin myth. Participants said that they experienced this freedom because they did not perceive themselves to be victims of negative bias from others in the group. It was this tacit acceptance and respect that led the artists and scientists to explore areas of similarity and convergence. This notion was critical to the success of the roundtables. Participants created a safe place - what Ury (2000) calls the third side - for conflict to arise, and even remain unresolved. They focused on the quality of the ideas presented and refrained from personalizing the conversations.

Ury's analysis was helpful for re-examining our data because it eliminated the possibility of dichotomous thinking. In such thinking, with two clearly drawn sides, there are essentially only two potential outcomes – one side wins, the other loses. This simplistic approach would encourage the perception of discord, because representatives of the two falsely separated sides could be interpreted as trapped in an all-or-nothing mentality. This analysis approach also allowed the researchers to discard codes that were inferred to be defensive when considered in isolation or described as misunderstandings by another member of the dialogue. On two occasions a new member to the group moved out of this conflict-safe framework but this action was quickly challenged by the entire group. Furthermore, given the freedom to join and leave the group at will provided a mechanism for group norming around the premise that conflict of ideas was healthy, but personal conflict was unacceptable.

The group conversations confirmed that all participants were highly observant. They used evidence to outline their understanding, and prior observations to ask probing questions or challenge their own assumptions. It's important to note that both artists and scientists were of the opinion that they are viewed as being on the fringes of society. Both groups also agreed that pursuing either art or science was a creative exercise in observation

of the world around them. According to one artist, both disciplines start out with a vision, and "then what they're doing is trying to see something in a different way." In several discussions, participants focused on why this view might create a conflict between their disciplines and the public when they try to communicate, given the focus on the language or customs used within each.

Consistent with small group behavioral research (e.g., Hogg, 2016; Sharif, 2015), participants worked to identify common processes as a code of conduct that would be consistent across the group, irrespective of their disciplinary customs. This practice created mutual respect that encouraged open exploration, but may have also suppressed observation of where conflicts might arise when the disciplines intersect. Both artists and scientists considered this collaboration an opportunity to break down stereotypes and perceived differences that separate the arts and sciences. For example, they highlighted that artists and scientists use many of the same tools. Participants also pointed out that they teach an "integrative message" as one of the artists called it. "If I create something beautiful that [a scientist] can tag onto," explained an artist, "and we both achieve the same purpose, it gains us both more exposure. For me it teaches the integrative message: life is not separating out…There's lots of sciences that go into what I do."

Both groups felt that nurturing a relationship between their respective disciplines would be fruitful. They offered a wide range of anecdotes describing collaborations they perceive as effective, specifically artists representing a scientific concept or an engineer constructing an art piece. They felt that true collaboration between the disciplines relied on jointly developing an idea, rather than one discipline conducting only the implementation. They noted that it is hard for true collaboration to happen organically, and identified disparate language, trust, investment, and desire as potential barriers to collaboration. All emphasized the importance of identifying common points of interest, as well as having mutual appreciation for one another's work to enable collaborations. The participants also felt that skillful interpreters could increase collaborations by drawing people from different backgrounds together and creating space to develop a common language and mutual respect. In retrospect, after our initial coding was complete, we realized that this desire for a skillful facilitator was a call for a third side that was emerging in the process. This idea was reinforced in the follow-up roundtable, where artists and scientists were presented with conflict theory and discussed how it could be applied to their experience.

An Example of Conflict Yielding Productive Results

There was widespread agreement among participants that Cynthia Pratt's Riverrun Revisited was the most effective demonstration of art-science conflict transformation within the I/CaLL initiative. They felt that the combination of the choreography with the voiceover allowed the dance to serve as a visual stimulus, while the audio counterpoint delivered concrete auditory information that could support science reasoning among audience members. The group also pointed out that the science content and choreography dynamically supported each other.

The collaboration resulted in greater public knowledge of the waterways in Indianapolis. Retrospective pre- and post-event self-reflection showed that science learning and communication increased following the performance. Specifically, participants reported a greater understanding of the scientific processes and phenomena after performance (*M* =

4.11, *SD* = 0.65) versus before (*M* = 3.00, *SD* = 1.19); t(44) = 8.19, p < .05). They also felt that they could better explain the science to others after the performance (*M* = 4.78, *SD* = 0.42) versus before (*M* = 4.09, *SD* = 1.06); t(44) = -.5449, p < .05). Attendees reported significantly stronger feelings about the capacity of art to communicate about science following the event (*M* = 4.51, *SD* = 0.51) versus before (*M* = 3.40, *SD* = 0.96); t(44) = -8.68, p < .05.

Our analysis suggests that the main reason for these positive outcomes was Pratt's commitment to building mutual trust in a way that didn't require compromise. Pratt did so through sustained engagement with scientists in iterative clarification and reconstruction of the work until it aligned with the scientific principles they sought to present. Of all the commissioned artists involved in the I/CaLL project, Pratt was also one of the most frequent attendees at the art-science roundtables.

Validity Testing of Theory

To test the validity of using conflict transformation theory to describe the relationship between artists and scientists, these findings were presented to the roundtable participants for discussion. Their comments revealed that conflict transformation theory is indeed a valid way of describing the participants' experience in the art-science roundtables. Participants saw conflict as pervasive within society, substantiating this paper's premise that conflict is a natural part of human interaction. As one participant articulated, "There's always going to be conflict. Some people are going to see it and be receptive to it, some are not."

Unsurprisingly, roundtable participants initially had trouble disassociating the word conflict from its negative connotations. For example, when asked if conflict could be a productive force in their work, one responded, "If I think of conflict in the sense of hostility, I personally get nothing out of it. It makes me less creative. But if by conflict you simply mean a conflict of ideas…people who are not always on the same wavelength can talk and work things out, then yes." Another summed up the group conversation on the topic saying, "It's really the distinction between conflict defined as hostility versus conflict defined as difference."

Participants asserted that the location and type of interaction around conflict determines its outcome. They contrasted the roundtable format with that of a more traditional academic conference, which tends to encompass a particular discipline and its practitioners, jargon, and value systems. They felt that roundtables brought people together in a venue where no one has home turf advantage. Participants noted that to be conducive to collaborative work, this physical place must also be characterized as an environment where ideas are shared and received in a nurturing way. This ensures that conflict advances the conversation rather than undermines it.

Participants described the dimensions of what they termed a "safe space." For example, one artist provided an example of two collaborators she works with. With one she feels her artistic integrity remains intact, making her more likely to be receptive to new ideas that change the nature or direction of her work, but she does not feel the same about the other collaborator. As the artist explained, "For one, there's a complete safety factor. If he raises a question, I feel thankful and open to any suggestions he makes. He would never say anything to make me feel lesser. I have another partner where there's an ego issue…If they

suggest I change the notes, it depends on the person. The first I would strongly consider, but the second I feel it's an ego thing."

The need for skilled facilitation

Participants continually expressed the need for an interpreter or facilitator, as a critical element of transforming conflict. A good interpreter has various roles in the art-science context. Foremost, they have the ability to facilitate a desired experience through the "pre-disposition to listening," rather than a didactic sharing of disciplinary expertise. Roundtable participants contrasted this approach with a more antagonistic event many had recently attended involving neuroscientists and artists in conversation without a skilled facilitator, where collaboration had not been an outcome.

The interpreter also helped set the stage for open-ended and exploratory dialogue instead of goal-oriented discussion. Participants appreciated the lack of a prescribed outcome, and that the interpreter did not identify a particular goal in advance. As described by the roundtable facilitator, "That's how I've invited everybody. We just get together and talk. What's the outcome? We just talk." Although not explicitly stated, participants pointed to the core distinction between conflict resolution, where resolving a particular conflict is the goal at the outset; and conflict transformation, a flexible process whereby conflict becomes a catalyst for a new knowledge, relationship and creativity. Our results demonstrate the third side, in the context of art-science collaboration dialogue process-driven. This does not mean that a product cannot be the eventual outcome, merely that a predetermined outcome cannot guide the collaborative process.

Discussion

Cultural theory suggests that meaning is created through knowledge that is accumulated and shared. As Lederach (1995) states, "understanding conflict and developing appropriate models of handling it will necessarily be rooted in, and must respect and draw from, the cultural knowledge of a people" (p.10). In this case, artists and scientists challenged a pedagogy that assumes a fundamental cultural divide that requires mediation or reduction to commonalities. The members of roundtables developed a mutually constructed safe space to explore collision and contradiction between their disciplines to support more meaningful production of knowledge. Participants were able to consider the knowledge in endeavors unlike their own, how cultural knowledge production feeds a larger human enterprise, and to appreciate the value of multiple perspectives for developing a richer understanding of how we inhabit and learn in cities.

The need for a facilitator/interpreter to help people from distinct disciplinary cultures navigate this process was abundantly clear in these dialogues. While conflict resolution professionals or mediators may claim a certain amount of neutrality in their approach, a more apt description may be omni-partial, in support of both sides at the same time. The transcripts revealed that the successful convenings occurred because the facilitator ensured a completely open process detached from the outcome or product. By encouraging participants to clarify assumptions and provide the basis of their claims, or even reframing a comment to help, the facilitator protected the space from biased perspectives that might have directed the outcome. The third side avoided perpetuating the

falsely defined conflict between two disciplines, and provided a container that could hold the conflict between perspectives as a valuable tension.

We introduced Bhabha's (1990) concept of third space to express the physical, emotional, and intellectual hybrid space that allows for learning to occur and deployed Ury's (2000) thesis of conflict transformation as our analytical lens. We assert that Ury's third side can only exist within the larger framework of Bhabha's third space. In so doing, we demonstrated that the physical, intellectual, and emotional safety can be created and provide the opportunity to find meaning, and gain understanding. The roundtables created a productive third space for participants to build a more complex understanding of their different approaches to knowledge production. These roundtables retained the cultures of art and science and allowed for future growth and revision of the icons and symbols within each discipline. All parties moved toward a deeper understanding that enhanced collaboration across the board. In a sense, the work of the roundtables and I/CaLL has uncovered a hybrid model of collaboration that cannot be either categorized as art or science.

Participants felt that the dialogues helped enrich their thinking about their own discipline. We suggest that this ability to use the knowledge horizon of another discipline as a test that challenges your own field is, in itself, a valuable outcome for both artists and scientists. The findings showed that this kind of collaboration enriches the questions and hypothesis generation that drives both the scientific process and the artists' pursuit of making tangible a phenomenon. Traditionally, much of the art-science literature has seemed to focus on a mediated product that would emerge when the two disciplines are brought together. Our findings suggest that the most valuable assets may not be a single product, but rather, two parallel products each uniquely advanced because of deep engagement with the knowledge horizons of the other. In some cases, these parallel products join together in a single presentation, as was the case with Riverrun Revisited. The work of the choreographer experimenting with scientific dialogue as the score to support dance uncovered a rich provocative approach that resulted in translational knowledge for the audience. That work was not, in itself, scientific interpretation, but rather scientific explanation that was made richer by the contrast of movements that made visible the phenomena.

This approach to studying art-science collaboration seems to suggest that the instinctive desire to avoid conflict may diminish the results of art-science collaborations, and that the instinct to simplify or reduce the richness of practice may not serve either profession well. These findings suggest that the work of art production and scientific inquiry will become stronger if each discipline brings their knowledge production process in its entirety to the conversation. Both can produce full work in their field: not synthesis but two new creations that will pass the test of highest order in their discipline and would not exist without the other discipline as instigator.

We suggest that this kind of collaboration can work with other interdisciplinary endeavors. The creation of third side in this context suggests that existing theories about cross-disciplinary conflict may need to be modified. The facilitator is the key to the emergence of a third side to any dialogue-based conflict and should focus on three interrelated pursuits: 1) Setting expectations for participation and learning; 2) Creating a safe

space in which a free exchange of ideas and opinions occurs without the fear of personal injury; and 3) Moving participants beyond a perceived need for outcome-driven conversations, focusing instead on exploration of the conflict in greater detail.

Conclusion

This paper describes a new way forward in art-science collaboration by exploring conflict as a way of deepening inquiry, and moving beyond consensus and instrumental value. The first step in the process of transformation is acknowledging that conflict is inherent in dialogic process and can be particularly strong between groups that have discrete and often isolated practices. A skilled facilitator can nurture a safe space for participants to transform the conflict into a new understanding of art-science collaborations, one that does not seek to merge the two but allows for the richness of each to be parallel paths to knowledge. By applying conflict transformation theory, we contend that there is no need to merge art and science, but rather that collaboration may be seen as an unfinished work that expands understanding through mutual willingness to remain engaged in the interpretive process.

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