Management Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

Emergent Life Cycle: The Tension Between Knowledge Change and Knowledge Retention in Open Online Coproduction Communities

Gerald C. Kane, Jeremiah Johnson, Ann Majchrzak

To cite this article:
Gerald C. Kane, Jeremiah Johnson, Ann Majchrzak (2014) Emergent Life Cycle: The Tension Between Knowledge Change and Knowledge Retention in Open Online Coproduction Communities. Management Science 60(12):3026-3048. http://dx.doi.org/10.1287/mnsc.2013.1855

MANAGEMENT SCIENCE
Vol. 60, No. 12, December 2014, pp. 3026–3048
ISSN 0025-1909 (print) | ISSN 1526-5501 (online)

http://dx.doi.org/10.1287/mnsc.2013.1855

Emergent Life Cycle: The Tension Between Knowledge Change and Knowledge Retention in Open Online Coproduction Communities

Gerald C. Kane
Carroll School of Management, Boston College, Chestnut Hill, Massachusetts 02467, gerald.kane@bc.edu

Jeremiah Johnson, Ann Majchrzak
Marshall School of Business, University of Southern California, Los Angeles, California 90089
{johnsonjeremiah@gmail.com, majchrza@usc.edu}

Online coproduction communities often face a challenge of whether to change or retain the knowledge they have created. Disparate and often conflicting theoretical models have been used to explain how these communities respond to this tension. We conducted a case study of how one online coproduction community—the nine-year history of the Wikipedia article on autism—handles this tension. We find that the nature of the change–retain tension and the community's response to it fluctuates considerably over the life of the community. These changes bear striking similarities to processes associated with traditional software development life cycles, despite the absence of traditional control mechanisms. What initially appear to be conflicts in the extant literature actually describe different roles and production focus at the different stages of development. Disruptive events signal the need for the community to shift production focus, which often involves members joining and leaving the production process, rather than adopting new roles.

Keywords: online communities; peer production; knowledge creation; social media; wiki; longitudinal
History: Received July 17, 2012; accepted September 16, 2013, by Sandra Slaughter, information systems.
Published online in *Articles in Advance* April 16, 2014.

1. Introduction

Open online coproduction communities involve loosely connected contributors, using an Internet-based platform[1] to make public edits to webpage content, yielding a common codeveloped information artifact (Faraj et al. 2011, Monge et al. 1998, O'Mahony and Ferraro 2007, Ren et al. 2007). These communities are open to the public, allowing contributors with their own objectives and interests to contribute at will. Many artifacts are coproduced in this way, such as collectively written troubleshooting guides in open source communities (Lakhani and Von Hippel 2003), encyclopedia-like reviews of topics in Wikipedia (Wagner 2004), synthesized healthcare data (Kane et al. 2009, Ransbotham et al. 2012), Web-based school projects in which students coproduce an article about a class topic (Kane and Fichman 2009), and coproduced travel documents on sites such as Wikitravel. Some of these artifacts, such as Wikitravel documents, have been codeveloped by thousands of contributors.

[1] Majchrzak et al. (2013) offer more details about wikis and their uses as knowledge management systems.

Considerable research concerning online coproduction has focused on why people contribute to production (Bagozzi and Dholakia 2006, Butler et al. 2002, Dholakia et al. 2004, Forte and Bruckman 2005, Jeppesen and Frederiksen 2006, Nov 2007, Rafaeli et al. 2005, Roberts et al. 2006, Wasko and Faraj 2005). Recent research, however, has emphasized the need for greater insight into how the coproduction process proceeds over time (Faraj et al. 2011). This study responds to that call by focusing on understanding the process by which online coproduction occurs. We focus specifically on how the coproduction community handles the tension between retaining the knowledge it has created or changing it in response to new perspectives, insights, or events. Balancing the need to retain and the need to change organizational knowledge has been an important process identified both in online coproduction communities (Kittur and Kraut 2010, Lee and Cole 2003) and in more traditional closed-source organizations (Kane and Alavi 2007, March 1991).

Research focused on the coproduction process has yielded equivocal results about how the process unfolds and the mechanisms required to support the process. On one hand, some research emphasizes

the importance of *organizational structure* early in the coproduction community, including the importance of early leaders providing the direction for the coproduction (O'Mahony and Ferraro 2007), substantial rules governing who resolves conflicts and how they get resolved (Butler et al. 2008), and preseeded artifacts (Lee and Cole 2003) to ensure adherence to this early direction. These early community structures bolster the formation of a core group within the community, who then guide new contributors so that coproduction continues in the intended direction as more experienced contributors eventually reduce their level of activity (Preece and Shneiderman 2009).

Other scholars have emphasized the *emergent dynamics* of the coproduction community as it responds to the change–retain tension (Faraj et al. 2011). New contributors bring new perspectives about the content in the artifact to which the community must respond to in ways that sustain the new contributors' involvement but also maintain production (Butler 2001, Ransbotham and Kane 2011). Then, the coproduction process that evolves the knowledge artifact is less predefined in this perspective by the organizational structure and, instead, is one of generative response to proposals that change the content over time. For example, in a longitudinal study of an open source software development community, an approach that assumed an organizational structure managed by a leader guiding the coproduction process throughout the knowledge artifact evolution did *not* explain the leadership changes that were necessary for codevelopment (O'Mahony and Ferraro 2007). Although an approach that emphasizes organizational structures may provide general rules and context for this evolution, it does not capture the highly individualized, transient, and unstructured response of individuals to maintain coproduction in fluid environments (Faraj et al. 2011).

This state of the extant literature has led to our research question: *How do online community contributors respond to the knowledge change–retain tension in order to facilitate coproduction*? We focus on the nine-year history of a community coproducing a Wikipedia article. Wikipedia is a collaboratively edited, free Internet encyclopedia in which almost all of its articles can be edited by anyone with access to the site.[2] Although the artifact being produced is an encyclopedia article, unique to Wikipedia, our intent is to generalize the findings beyond this context to describe emergent patterns of online coproduction communities in general.

Our examination yielded three findings. First, unlike suggestions in the literature that community action is either prestructured or emergent, individualized, and unstructured, we found the existence of three emergent interaction patterns of activities characterized by different focus of coproduction and different patterns of behaviors that help to maintain coproduction. Second, these patterns are heterogeneously distributed over the lifetime of the coproduction process such that different people engage in the different patterns at different times. Shifts in patterns appear to be enacted in response to disruptive events initiated from outside the community that cause shifts in the knowledge change–retain tension and concomitant shifts in responses to the tension. Third, contributors to the coproduction community tend to focus their contributions on particular patterns. Thus, instead of shifting their patterns, they join and leave the community at the times when a particular pattern can be applied.

These findings have important implications for our understanding of how online coproduction communities produce an artifact. Our findings suggest that the process of online production is neither highly structured nor completely emergent; rather, it that can be predicted based on shifts in the knowledge change–retain tension over time and patterns of responses to those shifts. We suggest that these shifts may constitute a model of coproduction that may reconcile certain extant competing views of the online coproduction process.

2. Conceptual Development

We first describe the nature of the knowledge change–retain tension in online coproduction and then conceptualize how contributors may emergently coordinate this tension.

2.1. Knowledge Change–Retain Tension in Online Coproduction

The knowledge change–retain tension among contributors in online coproduction communities has been documented by a variety of researchers. For example, Kittur and Kraut (2010) documented repeated conflicts within the development of Wikipedia articles concerning whether knowledge in the article should be changed or kept the same; they found that the overall level of conflict grew with increasing numbers of contributors. Similarly, Lee and Cole (2003) describe a knowledge change–retain tension in an open Linux coproduction community in which peripheral contributors in the community identified problems with the existing software code, but the core group that wrote the software code insisted on retaining the existing code, refusing to make the change. To resolve this tension, the community created a formal division of labor in which peripheral contributors formally lodged their complaints about the code, and

[2] http://en.wikipedia.org/wiki/Wikipedia (accessed February 27, 2014).

then a core group of developers decided which complaints to convert into "patch projects" to be developed by the community. Although only 23% of the complaints ultimately became patch projects, Lee and Cole (2003) argued that the periphery appeared comfortable that their complaints had been heard.

In another example of the knowledge change–retain tension in wiki-based knowledge management systems, the unfettered addition of knowledge by masses of contributors has been found to turn wikis into disorganized knowledge repositories with both explicit and hidden redundancies and a lack of uniformity in semantics and content (Majchrzak et al. 2013). Bryant et al. (2005) found this knowledge change–retain tension so palpable that novice users of Wikipedia were reticent to add or change pages. In their study of open source software (OSS) projects on SourceForge, Stewart and Gosain (2006) similarly found the presence of the knowledge change–retain tension manifested as an adherence to certain ideological components of OSS (e.g., collaboration and forking norms) that were beneficial to attracting knowledge change proposals from contributors; yet these norms also led to a lower quality artifact. The authors concluded that there is a trade-off between producing outputs acceptable to some but not acceptable to all. Because of the highly fluid nature of membership in online communities (Butler 2001, Ransbotham and Kane 2011), this tension is likely to continue throughout the coproduction process, as new contributors either supply new knowledge that they want to see added or become committed to stabilizing knowledge already coproduced.

The knowledge change–retain tension has historically been defined as a trade-off. On the knowledge *change* side, any online knowledge production effort depends solely on the voluntary contributions of substantial numbers of people who come and go freely, which ensures that the artifact is inclusive, comprehensive, and accurate. Volunteers engage in these efforts so that they can have an impact on the common good or make a personal mark on the final artifact (Monge et al. 1998). The extent to which volunteers have direct impacts on the final artifact determines the extent to which they continue to contribute and produce (Kalman et al. 2002). Yet, on the knowledge *retention* side, well-intentioned volunteers may make changes that harm the artifact by making it disorganized and redundant. In addition, vast public attention about a topic might lead volunteers to contribute so much that they overwhelm the current organization of the artifact. For example, in the days following a campus shooting, volunteers made so many changes to the Virginia Tech Massacre article on Wikipedia that it was difficult for other volunteers to perform fact checking as well as refine and reorganize ideas to keep the article accurate and readable (Kane 2011). In summary, the knowledge change–retain tension is driven on one side by forces to stabilize knowledge already community created in the artifact and on the other side by the recognition that limiting volunteer contributions starves the knowledge coproduction effort.

2.2. Community Responses to Maintain Coproduction

Tensions can be influenced partly by formal structures, such as formal leadership (O'Mahony and Ferraro 2007) or procedures (Lee and Cole 2003). In Wikipedia, for example, there is a formal "three-revert" rule in which, after three rounds of an article segment being changed by one contributor, then reverted by another contributor, then changed again by the first contributor, the tension is elevated to an arbitration committee (Butler et al. 2008). However, these formal structures do not explain how the surfacing of this tension can be used as a catalyst for further coproduction (Kudaravalli and Faraj 2008). One perspective on how communities respond to the knowledge change–retain tension is suggested by Faraj et al. (2011), who argue that coproduction involves community members willing to "be generative" (i.e., cocreative) in response to each specific occurrence of the change–retain tension. By generative, they mean actions taken by individuals in the community that foster a discussion about the tension in a manner that engages multiple perspectives and an eventual resolution through the creation of new knowledge. The opposite of "generative" in this context would include actions taken by contributors to end the discourse, through fiat or formal community authority, thereby harming additional coproduction.

Generative responses occur during deliberations focused on specific proposals offered by contributors for knowledge changes to the artifact. Defined by Pava (1983), a deliberation is a discussion between two or more people about a topic for which there is an initial disagreement. In an online coproduction community, deliberations may last minutes or months depending on when contributors join the deliberation and when resolutions are developed. There may be many or few deliberations over the course of the coproduction process, depending on the contentiousness of the topic.

We find no empirical research in the literature that investigates whether patterns of generative responses help sustain knowledge coproduction over time in the face of the knowledge change–retain tension. Moreover, it remains an open empirical question as to why people would engage in these patterns, if they existed. Faraj et al. (2011) theorize that the application of generative responses is situation specific without specifying the precise nature of the situational characteristics

that affect the use of particular generative responses. It is thus an open question as to the situational characteristics affecting the use of generative responses.

Additionally, we do not know if the same people apply the same patterns of generative responses consistently over time. Prior studies of open coproduction communities imply that certain behaviors in the coproduction process (such as conflict resolution, rules enforcement, and information shaping) are repeatedly performed by the same people, even if contributors are offered the opportunity to engage in other behaviors (Lee and Cole 2003, Majchrzak et al. 2013, Preece and Shneiderman 2009). Nevertheless, Faraj et al. (2011) suggest that patterns of generative responses may be enacted by different contributors based purely on who is online at the time rather than who performed the behavior previously. It is also unclear whether the same generative responses are consistent over time throughout production. Research on online coproduction communities indicates that the evolution of a community's production process is replete with disruptions (O'Mahony and Ferraro 2007). These disruptions may prompt cognitive and attention shifts from the automatic performance of routines, toward more conscious information processing, as the contributors shift from reflexive to reflective behaviors (Zellmer-Bruhn 2003). Disruptions, then, may create a stimulus for changing patterns of generative responses to maintain knowledge coproduction.

Therefore, we examine whether patterns of generative responses emerge during knowledge change–retain tension deliberations in an online coproduction community. We also examine whether the patterns of generative responses are affected by disruptions in the production life cycle that create opportunities for reflection and adjustment. The precise nature of these emergent generative responses within an online coproduction community is underexplored. Without an empirical search for patterns, we do not know if such patterns exist, when and how they are invoked, and how they affect the coproduction process. Therefore, in the remainder of this section, we offer a theory-driven framework for characterizing generative responses into patterns. Our framework consists of two types of community actions that previous literature has observed as facilitating coproduction: (1) sets of transient behaviors (Faraj et al. 2011, Majchrzak et al. 2013) and (2) dynamically adjusting the coproduction focus of the community (Butler et al. 2008, Faraj et al. 2011, O'Mahony and Ferraro 2007).

2.2.1. Transient Behaviors. Although most research on online communities has focused mainly on formally appointed structural behaviors such as administration and governance (Butler et al. 2008, Forte et al. 2009, Ransbotham and Kane 2011), there is some research on online coproduction that suggests there may be a number of informal self-defined behaviors that individuals may use on a transient basis to generatively respond to emergent tensions. These transient behaviors are different from formal positions (e.g., Wikipedia administrator) in that contributors only exert the behaviors situationally, based on whether the contributors happen to be online when it appears that action is warranted and only as long as the action seems to be needed (Faraj et al. 2011). Thus, the behaviors are transient for the individual because they are only performed as long as action seems to be needed, and they are temporary for the community because they are likely to be only needed situationally.

We follow Faraj et al. (2011), borrowing from an interactionist or emergent view of roles (Dansereau et al. 1975, Goffman 1961), by referring to a set of transient behaviors as enacted roles in the moment, and individuals who engage in these behaviors as enacting the roles on a transient basis. That is, the same individual may enact different roles at different moments, depending on what is perceived to be needed. The roles, then, are individually (not organizationally) enacted, given the particular situational context of the deliberation and without regard to the amount of time they have spent in the community. For example, an informally enacted in-the-moment role often seen among contributors in Wikipedia is that of conflict resolution because official administrators are explicitly prohibited from using administrative tools to resolve a dispute in which they are involved.[3] This description of enacted in-the-moment roles is different from that posed by other theoretical models of participation (e.g., Lave and Wenger 1991, Preece and Shneiderman 2009) that emphasize tenure of the individual in the community as determining which roles are enacted.

Previous research has observed several possible behaviors that may be enacted on a transient basis to facilitate online coproduction with respect to the change–retain tension. We describe three here. One such behavior is *adding content* to the information artifact, such as by adding a new fact, providing additional conditions in which a problem occurs, or adding a new perspective on a solution to a problem (Fulk et al. 1996, Majchrzak et al. 2013). When diverse individuals from the community enact the transient behavior of adding, coproduction is facilitated through a more comprehensive, multiperspective understanding of the topic (Boland and Tenkasi 1995). Another enacted transient behavior observed has been referred to as *shaping* (Majchrzak et al. 2013,

[3] http://en.wikipedia.org/wiki/Wikipedia:Administrators (accessed February 27, 2014).

Yates et al. 2010), in which individuals reorganize already posted contributions to ensure readability, reduce redundancies, and codevelop a more organized artifact for others to use. Shaping behaviors helps coproduction by making it easier for others to recognize how new content that a contributor considers adding to an artifact could relate to existing knowledge (Majchrzak et al. 2013). A third and final behavior that we describe from the literature for online coproduction communities is *discourse facilitation* in which individuals may moderate conflicts among online contributors (Kim and Bateman 2010). When conflicts can be moderated to focus on the task, rather than devolving into interpersonal conflict, disagreements will be more quickly resolved (Jehn et al. 1999), helping to foster coproduction. Some communities choose to assign a formal moderator role, but many other communities relegate discourse facilitation to those who happen to be participating at the time that facilitation is needed (Kane 2011). These three (and possibly more) enacted roles may help foster coproduction when transiently enacted as they are needed.

Although the online communities research reviewed above has identified the existence of the three transient roles of adding, shaping, and discourse facilitation, there is little research that relates these roles to online coproduction, describes how these roles are distributed across the community, and depicts when these roles are used during a coproduction process. Although Faraj et al. (2011) suggest that the roles are likely to be emergently applied to each deliberation in a unique fashion by different individuals because each deliberation is unique, others have suggested that anyone and everyone can and should enact any of the roles at any point in time (Majchrzak et al. 2013) or that only a core group is likely to engage in discourse facilitation (Kuk 2006, O'Mahony and Ferraro 2007, Marwell and Oliver 1993, Preece and Shneiderman 2009). Therefore, our research examines patterns of these transient behaviors in terms of when they occur, by whom, and to what effect.

2.2.2. Shifting Production Focus. A second type of community action that has been observed in previous literature that may explain how online coproduction is fostered are behaviors that dynamically shift the knowledge boundaries that define the focus of the production at any point in time (Boland and Tenkasi 1995, Faraj et al. 2011, O'Mahony and Ferraro 2007). Lamont and Molnar (2002) distinguish two forms of boundaries, social and symbolic, and consider the latter more fundamental. Symbolic boundaries are "conceptual distinctions made by social actors to categorize objects, people and practices…tools by which individuals and groups struggle over and come to agree upon definitions of reality" (p. 168). Symbolic boundaries require community members agreeing on terms, criteria for evaluation of knowledge, and knowledge content that is in or outside of the perspective (Boland and Tenkasi 1995). As such, symbolic boundaries create a coproduction focus for a community by defining the knowledge content of the perspective under development vis-à-vis other perspectives and, therefore, the "making" of the community's perspective versus the "taking" of other communities' perspectives (Boland and Tenkasi 1995).

This coproduction focus is likely to change over time as perspectives evolve through differentiation and strengthening. Just as the field of biochemistry evolved through the shifting of production focus from biology and chemistry separately to a production focus on biology and chemistry combined (Edsall and Bearman 1979), the production foci of online coproduction communities are likely to shift as members redefine the symbolic boundaries around membership, contribution, and meanings between communities.

In the case of the online knowledge change–retain tension, symbolic boundaries then are manifest in the focus of production during the deliberation, defined as the nature of the change–retain tension (i.e., what the deliberation is focused on), and the nature of the interactions between roles engaged in during the deliberation to resolve the tension. The existence of distinct foci necessary for developing and maintaining valuable knowledge has been noted throughout the literature (Alavi and Leidner 2001, Argote et al. 2003). However, there is little as yet understood about the nature of this production focus, how it may influence deliberations with respect to the knowledge change–retain tension, or how this focus may shift over time.

2.2.3. Summary. In sum, we propose a conceptual framework in which an online coproduction process consists of a series of knowledge change–retain deliberations that are generatively responded to by the community. These responses, enacted during the deliberation, will take two forms: transient behaviors depicting roles enacted in the moment during the deliberation and shifting patterns of deliberations with different foci of production. Our case study was intended to explore the nature of these roles and patterns.

3. Research Setting and Method

We first describe an overview of our case, the data we used to conduct our analysis, and confirmation that coproduction occurred throughout the history of the case. We then describe our deliberations analysis, including how the deliberations were coded. In

the following two results sections, we first present the patterns we identified, and then we present an analysis of the patterns over time and across contributors.

3.1. Overview of Case: Autism

We undertook the collection, integration, and examination of data related to the coproduction of the Wikipedia autism knowledge artifact over its nine-year period from its founding to the present time. We selected the autism article because it has had a large number of discussion threads since its start in 2001 (393), had experienced distinctive disruptive events in its coproduction history, and is widely read as a major source of knowledge about autism.[4] The development of the autism article involved 3,181 unique individuals making 8,341 changes to the article during our period of analysis. This significant coproduction attention was in large measure due to the diversity of opinions about definitions, causes, treatment, and prognosis for autism that continue to exist today (Dixon and Clarke 2013), and the diversity of contributor knowledge associated with the topic (ranging from parents of autistic children, autistic individuals, alternative medical practitioners, educators, pharmacologists, nutritionists, and medical professionals). Three disruptive events occurred at three specific times during the coproduction process:[5] First, when the article was recognized by a Wikipedia committee of judges who were not involved in the article's coproduction process to be a "featured" (i.e., high-quality) article (August 10, 2005); second, when the article was demoted from its quality status because of poorly sourced information, disjointed information, and chaotic organization (December 17, 2006); and third, when the article was repromoted to featured article status (August 14, 2007), which it maintains today. The autism article was one of only 30 articles that had experienced this promotion-demotion-promotion cycle, making it a relatively unique setting to observe how disruptive events affect the change–retain tension. We stopped data collection at the end of 2010.[6] Our methodology consisted of six steps:

1. Searching Wikipedia archives to determine when promotion and demotion occurred and the reasons.
2. Organizing every talk page post, article change, and personal user pages into a database, depicting a detailed timeline of each production action taken and interactions among contributors related to each production action.
3. Coding the production action timeline to identify deliberations and reorganizing the timeline database by deliberations.
4. Obtaining Wikipedia statistics over time of coproduction (number of views, visitors, and changes).
5. Inductively coding deliberations to identify patterns of generative responses.
6. Quantitatively analyzing generative response patterns across time, contributors, and disruptive events.

A summary of the data sources we used is shown in Table 1.

We first consolidated the data sources by chronological order to ensure that information related to the article's complete evolution, such as contributions, contributor profiles, and public discussions between contributors on their respective profile pages, were included. The integrated database consisted of a detailed timeline indicating the sequence of online actions and who took them, such as whether an article page change was made and when, whether the change was discussed on the talk page, whether the changes to the article page were revised or reverted, and who else contributed in discussing the change on the talk page or making changes on the article page. This timeline was first analyzed to confirm that coproduction occurred throughout the nine-year history of our study. We used both the autism article page changes (referred to as edits) and the talk page changes to examine the distribution of contribution over time. Utilizing these data, we compared quarterly activity on the article page and the talk page by summing up all the editing activity on that page for each quarter. We also calculated the number of unique contributors who took part in the deliberations during each quarter. The results are shown in Figure 1.

Figure 1 indicates that edits to the article page continued to occur throughout the nine-year history, even as the article matured. Additionally, the number of unique contributors in each quarter indicates that large numbers of individuals were involved throughout the history of the article page. We examined changes in article length and found no significant changes after the final promotion, indicating that the contributions were primarily intended to improve the existing content, suggesting a knowledge change–retain tension. Over the nine years, the average number of unique contributors making changes to the article page in each quarter was 97.8, and the average number adding comments to the talk page was 18.1 per quarter. These contribution numbers varied over the article's history, but since the first promotion, the number of quarterly article contributors

[4] The autism article consistently ranks among the top 2% of views of all English-language Wikipedia articles (250,000–350,000 views/month) during the period of analysis for which data was available.

[5] The information about the reasons for these disruptions came from the featured article review process, which occurs on a separate wiki page dedicated to the review and consideration of featured articles.

[6] For each subsequent revision of our paper since we ceased data collection, we revisited the collaboration that has occurred since our study ended. We found no evidence that the collaboration that has occurred since we stopped collecting data affects our results presented in this paper.

Table 1 Data Sources and How Each Data Source Was Used

Data source	Description	Usage
Repository of changes made to the article page	All 8,341 previous versions that highlights how each version differs from the one preceding it	Identified the order of changes, which changes were made, and the individual who made them; integrated into deliberations for coding
Entire history of discussions recorded on the talk page	393 discussion threads, with comments and replies, with identifiers of each individual contributor	Identified deliberations as discussions focused on separate changes to the article page; integrated with article page changes to determine order of changes relative to discussions about them; served as the basic data for coding
Contribution history of each contributor to the article and talk pages	Wikipedia-developed search tool that finds all changes to the article page and additions to the talk page made by a specified user identifier	Used to calculate the number of unique contributors to article page and deliberation per time period, the highest-volume contributor, and whether a contributor was a newcomer (i.e., whether the contributor had not made previous edits to the article page at the time of contribution)
Personal user pages	Contains additional communications between contributors	If additional discussions ensued, added to the deliberation
Information about promotion, demotion, and promotion	Discussions related to granting and revoking featured article status from the nomination page	Used to create graphs of distribution of contributions over time and to understand why the article was promoted and demoted

never dropped below 38, and the average number of talk contributors never dropped below 12. These data indicate that the autism article received significant attention from its online community throughout its history of coproduction.

3.2. Deliberation Analysis

In this step of the methodology, we focused specifically on the deliberations that occurred over time. Below we first describe how we identified deliberations and then how we coded the deliberations for generative responses. We defined knowledge change–retain deliberations as consisting of an interaction between contributors on the talk page (i.e., one of 393 discussion threads on the talk page) and a corresponding change or retention of the information on the article page. To identify deliberations, we looked for an initiating event that was either an actual change to the article page that instigated discussion or a proposed change offered as an initiating comment on the talk page. We then identified all article page changes and talk page discussion threads that ensued concerning the initiating event, and we grouped them into a single deliberation. The deliberation ended when talk page comments for that discussion thread indicated resolution (e.g., "OK" or "I can go with that") or no additional comments or changes to the article page were added, indicating that the change–retain discussion was concluded. Of the 393 discussion threads, 143 consisted of small, noncontroversial editing changes (e.g., capitalization or adding a citation with no dissenters), personal concerns, or administrative discussions. Eliminating these from our analysis left 250 discussion threads focused on knowledge change–retain issues, which we hereafter refer to as "deliberations."

Figure 1 Contribution per Quarter

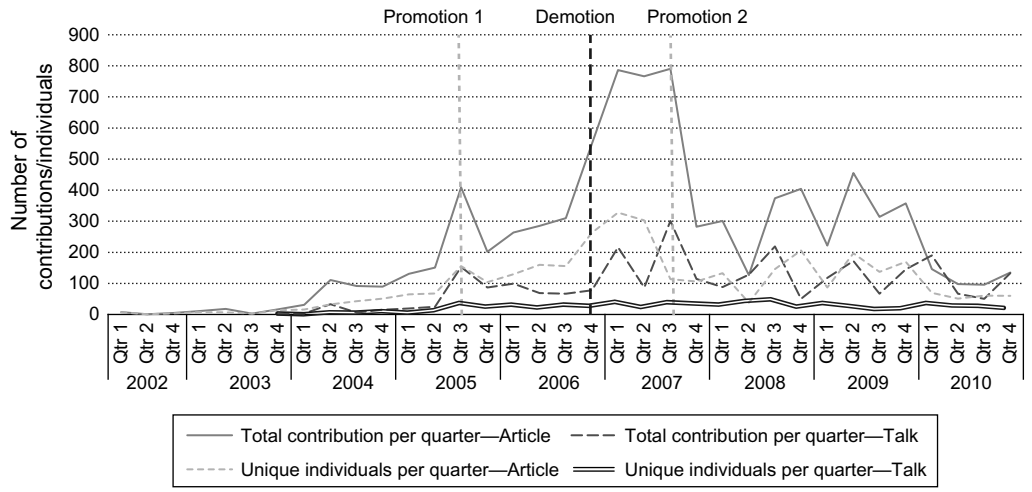
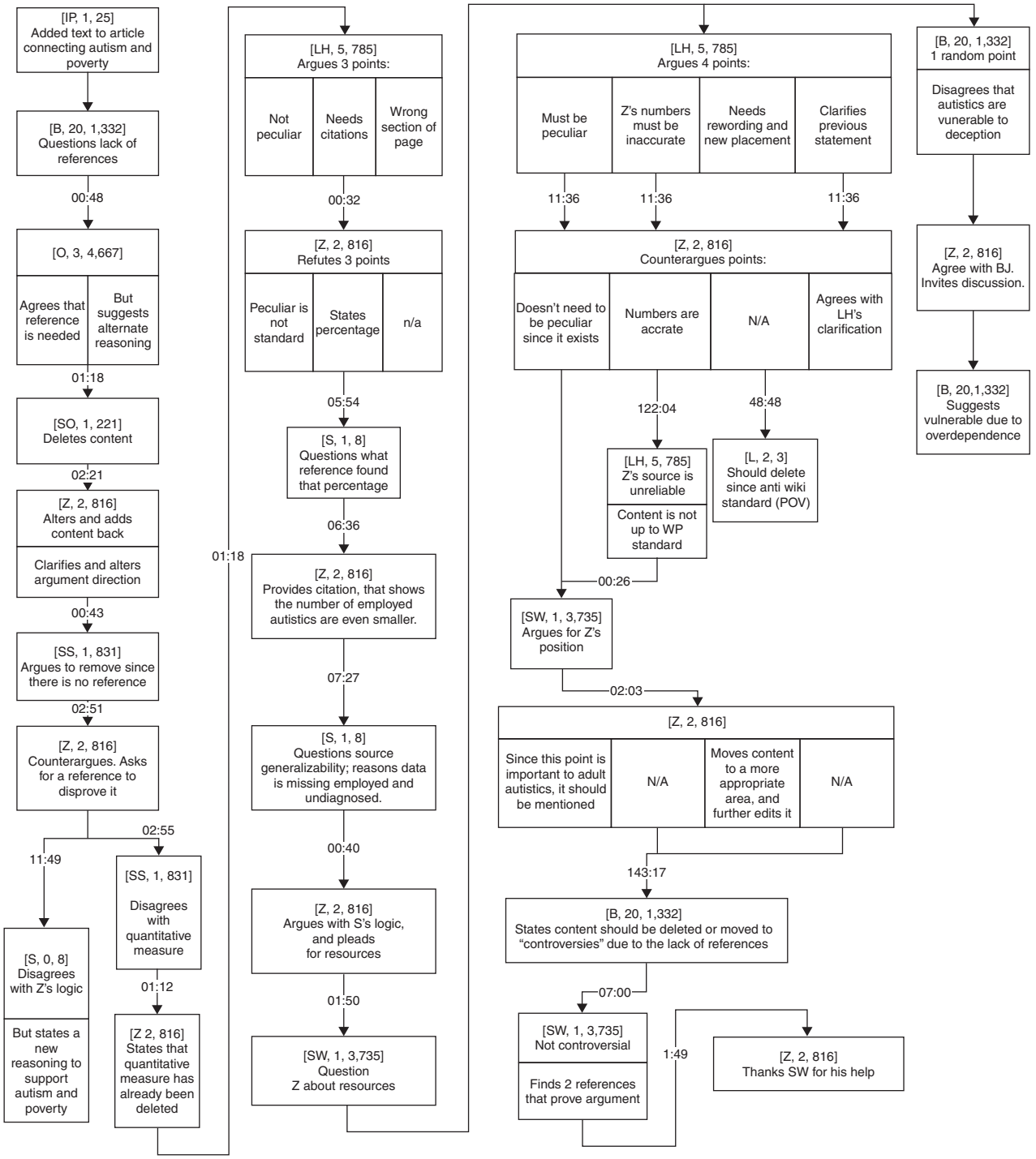


Figure 2 Deliberation-Specific Timeline of Actions for "Autism and Poverty" Deliberation



The length of the 250 deliberations ranged from 2 to 56 comments on the talk page (mean = 6.7 comments per deliberation). The deliberations involved 2 to 15 unique contributors (mean = 3.3 per deliberation). The elapsed time for the deliberations ranged from a few minutes to two months. For each deliberation, we created a deliberation-specific timeline of actions that we used to reveal what action started the deliberation, how the deliberation was resolved, the topic or article change that the deliberation focused on, the number of comments in the deliberation, the number of people involved in the deliberation, the highest-volume contributor to the talk page during the deliberation, and the actions taken by each contributor during the deliberation. Figure 2 presents an example of a deliberation-specific timeline for one deliberation in our analysis.

For each box, the initial of the commenter is followed by (1) the total number of contributions by this user to the autism article and (2) the total number of contributions by this user to any Wikipedia article at the time the deliberation began. The numbers between each box indicate the elapsed time in minutes. The boxes are the action taken on the article page or comment made on the talk page. When a box is split into subboxes, each subbox represents a different response. This deconstruction facilitated easier comparison of deliberations with one another.

3.3. Inductive Coding of Deliberations into Generative Responses

For each deliberation, we looked for evidence of the two generative community responses to the knowledge change–retain deliberation: (1) enactment of any of the three transient behaviors of content adding, knowledge shaping, or discourse facilitation, and (2) focus of production, defined as the types of modifications that are made to the artifact to improve it. The authors then iteratively coded the 10 longest deliberations, following Glaser and Strauss's constant comparative method (Glaser and Strauss 1967, Strauss and Corbin 1990). For these 10 deliberations, we developed attributes for coding in which the different values of each attribute could be examined to indicate different resulting patterns of enacted roles and production focus. The attributes provided information about the initiation of the deliberation, the response of individuals involved, and the final resolution.

The coding proceeded by examining a deliberation, noting the values of each attribute that were observed during the deliberation, and then assigning a value for an attribute based on a substantial majority of the activity occurring during the deliberation. After a 30-deliberation trial run to verify that the majority-attribute coding scheme would produce consistent results, two graduate student coders subsequently coded the attributes and their values for half of the deliberations through an iterative process of reading each deliberation and coding the majority attribute values for the deliberation. This process yielded an 88% interrater reliability between the coders with discrepancies reviewed and resolved by consensus adjustment to the definitions. The remaining deliberations were coded using the revised definitions. Table 2 presents the final set of attributes, definitions, and the possible range of coded values for the attribute. The online appendix (available at http://profkane.com/publications.html) provides illustrative quotes for each attribute value. The last column of Table 2 indicates patterns of attribute values that co-occurred in the same deliberations; these patterns will be discussed in more detail in the results section.

4. Results

We present our results to answer the research question: How do online community contributors respond to the knowledge change–retain tension in order to facilitate coproduction? We present our results in subsections, corresponding to our three findings: (1) the identification of three emergent (i.e., unplanned) interaction patterns of different roles and production focus, (2) the distribution of the patterns of the production process, and (3) the participation of different people in different roles. We also cross-referenced our results with major technical and policy changes in Wikipedia (e.g., the ability to "watch" changes to a page) to ensure these platform-level changes did not meaningfully affect our findings at the production level.

First, we conducted iterative coding of the deliberations and then grouped similar coding patterns and identified three response patterns with each consisting of its own distinctive production focus and manifestation of temporary behaviors (§4.1). We labeled the three response patterns: chaotic generating (CG), joint shaping (JS), and defensive filtering (DF). Once the three patterns were identified and examined independently, we then sought to compare the different patterns more deeply both qualitatively and quantitatively to identify key points of commonality and difference between them. Second, we examined how these deliberation response patterns were distributed across time (§4.2). We plotted the deliberations on a timeline, examining when the different generative response patterns occurred over the life of the article and across the discrepant events (i.e., promotion or demotion of the article). Third, we plotted the involvement of contributors over time indicating when they started and stopped contributing to the production process, the types of deliberations in which they were involved, and the roles they played in the deliberations (§4.3).

4.1. Identification of Three Generative Response Patterns

We examined the co-occurrence of attribute values across the 250 deliberations. This examination yielded three distinct patterns of co-occurrence, which we have labeled as three generative response patterns: CG, JS, and DF. The specific attributes associated with each of these response patterns are shown in Table 2. Each of these three patterns is described in detail below using an in-depth analysis of a single deliberation that occurred within the pattern. We chose as illustrative examples deliberations that were representative of the attributes of the response pattern and for which the outcome of the deliberation was similar (a modified acceptance of the change) to demonstrate that outcome is not a differentiator between response

Table 2 Coding of Deliberations

Deliberation attributes and value			Patterns of co-occurring values
Attributes	Description	Values	Associated pattern
1. Tension	What initiated the deliberation?	A. Someone made changes to the artifact	CG, DF
		B. Someone proposed changes to the artifact	JS
2. Initiator participation	Who performed the action that created the tension?	A. Someone who stayed to participate in the deliberation	JS, DF
		B. Someone who did not stay to participate in the deliberation	CG
3. Initiator tenure	Had the deliberation initiator contributed previously to the community?	A. The initiator had previously contributed	CG, JS
		B. The initiator had not previously contributed	CG, DF
4.Deliberation emphasis	What issue is there disagreement over?	A. Disagreement over whether the content to be added to the article is valid	CG
		B. Disagreement over how to organize the content already in the article for improved readability, searchability, and prose	JS
		C. Disagreement over whether content to be added to the article is substantially different from what is already there	DF
5.Community reaction	How do individuals react to the tension?	A. Amend the change and attempt to improve it iteratively	CG
		B. Offer, solicit, and implement feedback from others on changes	JS
		C. Rejecting changes and require justification from the initiator	DF
6. Had individuals cocreated previously?	Had the individuals worked together in a previous deliberation?	A. No/few	CG
		B. Most/all	DF, JS
7. Basis for group action	What norms are the bases for group coordination?	A. No group action	CG
		B. Coordinated action based on references to Wikipedia rules (e.g., "POV means…")	JS
		C. Coordinated action based on references to previous decisions made in the production process (e.g., "we've already decided this")	DF
8. Resolution strategy	Which negotiation strategy seemed to describe how individuals achieved final resolution of the deliberation?	A. Integrative (most individuals sought out a solution that could be acceptable to both sides)	CG, JS
		B. Distributive (most individuals failed to offer compromises or show regard for adapting to alternative perspectives)	DF

patterns. We then compare the similarities and differences between the different generative response patterns through both qualitative and quantitative analysis.

4.1.1. Chaotic Generating (CG). Of the 250 deliberations, 32 were coded CG. The focus of production was on generating new content for the information artifact, which often consisted of multiple generation efforts occurring in parallel. The nature of the change–retain tension focused on whether the content that was being added to the artifact was accurate and complete.

The knowledge change–retain tension in this type of deliberation was initiated by a content changer, who made changes to the article without previously vetting these changes through the talk page. Content retainers responded by removing the change, arguing that the change to the artifact was either inaccurate or incomplete. In response, individual deliberation facilitators resolved differences between content changers and content retainers through dialogue and iterative article changes to improve the content that would be included in the artifact. The original content changer often did not stay to participate in the deliberation, and additional content changers often amended the initial article change iteratively to eventually meet the objections of multiple content retainers. Nevertheless, even if multiple content changers and content retainers participated in the same deliberation, they operated as independent individuals with distinct perspectives. The final resolution of a coproduced change to the article was often one that attempted to meet the concerns of the various contributors involved, sometimes requiring several iterations.

To illustrate this response pattern, we use a deliberation concerning the relationship between autism and poverty. This single deliberation consisted of nine different contributors making a total of 40 contributions, yielding 135 lines of text and 25 changes to the article over 12.5 days. The timeline presented earlier

in Figure 2 depicts the timeline associated with this deliberation. The deliberation, initiated by an individual who was only identifiable by an IP address, posted a 112-word paragraph:

> [Autism] is the third-ranking leading cause of poverty in the world . . . Autism is considered to be one of the leading causes of poverty, due to their lack of social capital and often lack of perception of the world normally. Often autistic people in the developing world are often easy targets for government corruption, due to their gullibility and sometimes lack of intelligence. Though there haven't been any studies on autism in the Third World, there has been a common belief that autism is more of a higher percentage in the developing world. Often it is believed that the autistic rate is higher in the Middle East, Balkan Peninsula, and Central Africa.

The disagreement among the contributors in this deliberation focused on whether this relationship between autism and poverty was accurate. The discussion that followed implied that the original content changer did not stay to participate in the deliberation, which differed from other deliberations in which contributors typically claimed and justified their contributions. Contributors B, O, and SO acted as content retainers and wrote on the talk page concerns about the inflammatory and improperly cited nature of this passage, with one deleting the entire paragraph. The original content changer never responded to the deletion or participated in the deliberation; however, Z stepped into the role of deliberation facilitator and posted on the talk page that, although the paragraph itself might be inflammatory, there was merit in including in the article some information about the relationship between autism and poverty. So Z reinserted the deleted paragraph but made some changes so that the paragraph did not sound inflammatory to accommodate the concerns of B, O, and SO. Three new entrants—SS, S, and LH—as well as B then each argued independently on the talk page with Z about the modified paragraph; Z repeatedly modified the paragraph on the article page to meet their concerns.

At the close of this deliberation, the final version of the article changed from an initial, several-sentence paragraph stating that autism *causes* poverty to a single sentence stating that *autism can be a poverty trap for the majority of adult and young autistics*. Finally, B argued that even that single sentence should be deleted for lack of appropriate citations. At this point, SW stepped in and offered a citation, resolving this final concern and ending the deliberation.

4.1.2. Joint Shaping (JS). Of the 250 deliberations, 54 were coded JS. In this case, the focus of production was on modifying existing content in the artifact to increase readability, searchability, and prose. The nature of the change–retain tension focused on the overall style of the article and on Wikipedia guidelines, such as the requirement that all articles maintain a neutral point of view.

A deliberation facilitator often initiated the deliberation by posting to the talk page a proposal for a new organization of the article and explicitly inviting feedback before implementing any changes. Content retainers then posted disagreements with the proposed reorganization on the talk page, allowing them to jointly cocreate the change prior to its inclusion in the article. The deliberation facilitator then made modifications to the proposal until all content retainers appeared satisfied. At this time, one of the participants in the deliberation stepped forward to play the role of content changer and make the agreed upon modifications to the article. The subset of individuals involved in this type of deliberation often cocreated with each other across multiple deliberations. They were mutually deferential to each other, gaining consensus on talk page before shaping changes made.

One particularly rich example of this response pattern was initiated by a deliberation facilitator, E. He proposed a change on the talk page by asking, "Any objections if I move the sections around to reflect the suggested order in the [Wikipedia Manual of Style]?" He noted that the basis for this suggestion was that the current structure of the autism article differed considerably from what was recommended by the norms and standards established by Wikipedia for this type of article (i.e., medical topics). E then added the following to the talk page, essentially preemptively announcing changes he wanted to make to the article:

> Basically, . . . we'd move "History" to just after "Epidemiology." We'd move "Causes" to be just after "Characteristics." We'd then insert new sections "Mechanism" and "Diagnosis" (much of the material already exists). We'd then move "Treatment" to after the new "Diagnosis" section. We'd move "Sociology" to after "Treatment" and rename "Sociology" to be "Prognosis." Then would come a new "Screening" section. Then the existing "Epidemiology" (followed by "History" as already mentioned).

E had not yet made these changes at the time of this posting; he appeared to be soliciting feedback from others before doing so. Several participants responded to the request and coordinated by referring to each other implemented by E. Approximately seven hours later, W indicated that he liked all but one proposed change to a section that appeared initially to violate Wikipedia norms about nonmedical content in medial articles. SG felt that the section was fine as is. E offered a proposal to moderate the difference between W and SG. SG disagreed with this proposal and suggested a way to rework

the section in a manner that W agreed with and that was consistent with established standards. When no objection was made, E announced his intention to step into the content changer role and make the agreed upon changes, and he concluded the deliberation by indicating that the changes had been made and describing what changes had been made. This deliberation lasted 1.59 days and consisted of nine posts, 547 words, and three contributors building on each other's suggestions.

4.1.3. Defensive Filtering (DF). Of the 250 deliberations, most (164) were coded into the DF pattern. The focus of production in this case was on protecting the content that has been created by the coproduction community, although allowing incremental changes to reflect changes in the topic. The nature of the change–retain tension focused on how well the new content fit with the existing artifact and whether it added value beyond what was already contained in it.

The knowledge change–retain tension in this pattern was initiated by a content changer who had not been previously active in the community making changes to the article but then stayed to participate in the deliberation. In this pattern, a content changer makes changes to the artifact, which are rejected by content retainers on the grounds that the content is not substantially different from the content already in the article. The emphasis of the ensuing deliberation is not just whether the content is valid, but whether the changes fit with or added value to the existing article. The content changer often argues repeatedly that the content is new, but the content retainers keep deleting the change. These content retainers work in a coordinated fashion to make it clear that the change is not acceptable. They work together in similar ways across multiple deliberations, even though the composition of the group serving as content retainers changes somewhat over time. Eventually the content changer ceases to participate. Insistent content changers and content retainers openly argue, with content retainers defending against changes, content changers finally quitting, and occasionally making artifact changes after a content retainer offers a change that will prevent similar types of arguments in the future.

An example of this pattern was initiated by a content changer, GC, who added a section to the article describing comments of a radio commentator opining that autism was a behavioral rather than medical issue. He added,

> Outside of the scientific community some still interpret autism as an unchecked behavioral problem. For example, ardent right-wing commentator Michael Savage characterized autism as "a fraud" and prescribed tough love for autistic children: "I'll tell you what autism is. In 99 percent of the cases, it's a brat who hasn't been told to cut the act out. That's what autism is."

ES, a content retainer, reacted to the change less than 30 minutes later, removed the article change, and noted on the talk page that he removed it because "this change counts as original research . . . and doesn't belong in Wikipedia. Also, the claim is not particularly notable (just as the witchcraft claim wouldn't be notable) for this section."

GC argued that he had added the information about the commentator to highlight some of the popular misconceptions regarding autism. ES commented that Wikipedia is not supposed to "rely on guesswork by uninformed commentators." GC replied less than an hour later, indicating that the commentator's claims were used as an illustrative example of biases in popular culture. ES and several other content retainers (W and T, who had participated in previous deliberations with ES) appeared to coordinate their actions by repeatedly deleting the changes made by GC and supporting each other's argument that the changes did not reflect decisions about the article that had been made earlier, nor provided additional value to the article. W and T argued back and forth with GC, offering some modifications to his change, but ES rejected them again and again and moved GC's article change to another article that he argued was more appropriate. GC would not be pacified and reinserted the paragraph. ES removed the article change, and GC stopped commenting. The content changer appears to have left the coproduction community at this point because we observe no additional contributions from this contributor for the remainder of our analysis window (three years).

One day after GC left, however, a series of interactions occurred between ES and T on the talk page under a subheading of the original deliberation, eventually leading to the following addition made to the article page:

> Although the rise of parent organizations and the destigmatization of childhood [autism] have deeply affected how we view [autism] (Wolff 2004), parents continue to feel social stigma in situations where their autistic children's behaviors are perceived negatively by others (Chambres et al. 2008), and many primary care physicians and medical specialists still express some beliefs consistent with outdated autism research (Heidgerken et al. 2005).

Thus, the deliberation was settled in a way that eventually led to a change in the article that defended the article from objections or inclusions similar to those suggested by GC's (that autism has not been completely destigmatized). GC's words, his use of the commentator, and the GC participant was not included in the talk page and final article changes for the deliberation.

4.1.4. Comparing Generative Response Patterns. A qualitative analysis of the patterns is shown in Table 3. This table reveals several commonalties. Three enacted roles in the moment appear to emerge in the deliberations regardless of the response pattern: content changers (who made changes to the content), content retainers (who opposed the changes to the content), and deliberation facilitators (who attempted to compromise to resolve the disagreement). However, the nature of these roles differed across the response patterns. Content changers during CG and DF patterns were physically making changes to the article although deliberation facilitators only proposed changes during JS. The deliberation facilitator works to resolve disagreements at different stages in the deliberation: interactively as changes are made during CG, before changes are made during JS, and after the changer has left during DF. We observed coordination across multiple deliberations by none of the participants in the CG response pattern, by all participants in the JS response pattern, and only by the content retainers in the DF response pattern.

Not only are there differences in the precise nature of the roles between the response patterns, but the

Table 3 Unique Features of Each Pattern of Generative Response

	Generative response pattern			
Label and definition	Chaotic generating (CG)	Joint shaping (JS)	Defensive filtering (DF)	Key differences between patterns
		Enacted roles in the moment		
Content changer (C): A person who makes a change to existing content	C changes existing content by adding new content to the article.	C argues for reorganizing aspects of the content for better presentation.	C changes existing content in article by adding new content or modifying existing content.	Differences focus on what is being changed: In CG and DF, C adds or changes content to alter its substantive meaning. In JS, C reorganizes existing content for stylistic purposes.
Content retainer (R): A person who seeks to reject the change in favor of status quo	R argues against change by C, citing specific reasons for rejection on the talk page. May or may not be coupled with deletion of C's change to the article.	R disagrees about aspects of proposed reorganization on the talk page and iteratively responds to C's modifications.	R immediately deletes the change on the article page and may or may not provide an explanation on the talk page.	Differences focus on how R responds to C's change: In CG, R cites reasons for objecting to change, possibly making improvements. In JS, R cites reasons for objecting, and suggests improvements. In DF, R rejects change, cites reasons only if C objects.
	Multiple Rs operate independently from one another, raising individual objections to revise change.	R works cooperatively with C and F to create consensus solution.	Multiple Rs operate in concert as a unified group to support one another and defend the status quo.	Differences focus on independence between Rs: In CG, Rs operate independently. In JS and DF, Rs exhibit collective action.
Deliberation facilitator (F): A person who offers compromises to resolve the C–R difference	F iteratively offers compromises by making changes to article to respond to each concern of each R and posting the reasons for compromise on the talk page.	F first makes a proposal on the talk page for a change to the article, soliciting feedback, and modifying proposal. Once feedback stops, F may become C and reorganize content.	After C leaves, occasionally F will enter deliberation and suggest changes to article that protect from similar future challenges.	Differences focus on how C–R differences are resolved: In CG, F resolves differences through iterative changes to content. In JS, F resolves differences before making changes. In DF, F does not resolve differences or does so after C leaves.
		Focus of production		
Nature of change–retain tension	Accuracy and comprehensiveness of content.	Integrated story, Wikipedia style guidelines.	Fit with the existing content, value added by change with respect to length.	Different criteria for justifying change.
Nature of interaction between roles and example sequence of interaction	C often leaves after change and does not interact with community. F is solicitous and conciliatory toward Rs until Rs drop dispute or agree to compromise.	C, F, and Rs relate constructively. Those insisting on adding content and not willing to discuss reorganizing content are ignored.	C and R both are defensive and combative. F only joins later when C no longer argues for change.	Differences focus on tone of discussion among C, R, and F: In CG, tone is dialogic. In JS, tone is deferential. In DF, tone is defensive.
	C→R1→F→R1→R2→F→R2	F→R1→F→R2→C	C1→R1→C2→R2→time passing→F (sometimes)	Differences focus on order of roles: In CG, change first then facilitate consensus. In JS, facilitate consensus then change. In DF, reject first then defend decision.

Table 4 Frequencies for Contributors Involved in Each Generative Response Pattern

	Chaotic generating	Joint shaping	Defensive filtering	Average	*t*	Degrees of freedom	Significance (two-tailed)
Number of unique contributors	62	39	134	78.33	2.73	2	0.112
Average number of unique contributors/deliberation	1.94	0.7	0.81	0.81	2.90	2	0.101
Average number of comments/deliberation	8.41	6.13	6.62	6.77	10.17	2	0.010
Average number of contributors/deliberation	4.09	2.64	3.13	3.3	7.71	2	0.016
Average number of deliberations/contributor	2.11	2.9	3.84	4.07	5.90	2	0.028
Average number of comments/contributor	4.34	8.64	7.93	8.35	5.23	2	0.035

focus of production differs as well. In the CG response pattern the focus is on adding new content, in the JS response pattern the focus is on structuring existing content, and in the DF pattern the focus is on protecting the content that has been created. The nature of the change–retain tension differs as a result of this production focus. Deliberations in the CG pattern focused on accuracy and completeness of content, in the JS pattern focused on story organization and integration with Wikipedia guidelines, and in the DF pattern focused on fit with and relative value compared with existing content. The tone of the interaction between roles differs as well ranging from dialogic (for CG), to deferential (for JS), to defensive (for DF). Finally, the sequence of interactions among the roles is different, ranging from change first and achieve consensus later (for CG) to consensus first then change later (for JS).

Thus, we found evidence of role enactment; however, how the roles are enacted is defined by the generative response pattern. Moreover, we found evidence of a shifting focus of production defined by the different response patterns.

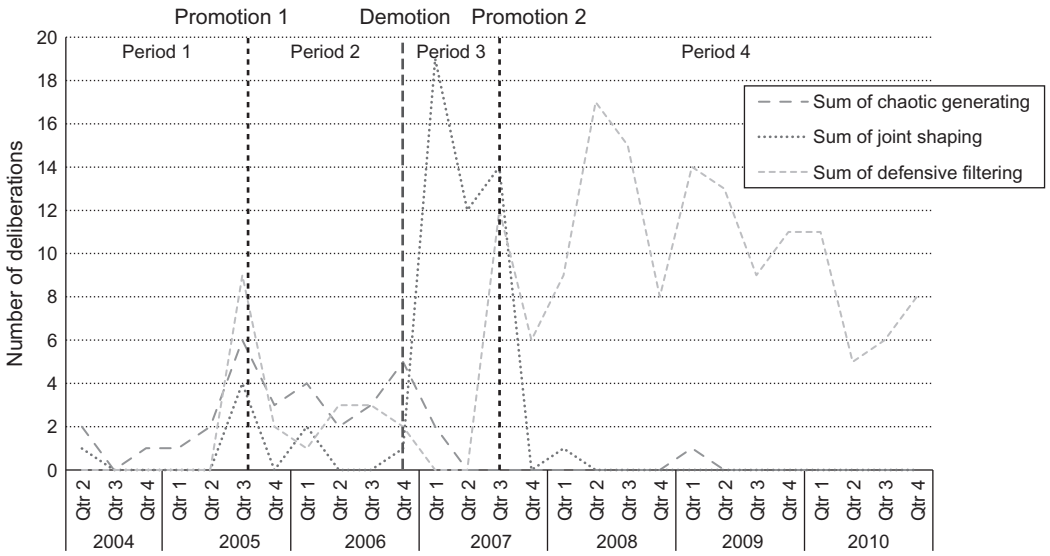
We then compared the different response patterns quantitatively with the frequencies for each generative response pattern shown in Table 4. These metrics are calculated across deliberation types. For instance, we calculated the average number of unique contributors/deliberation by adding the total number of unique contributors to deliberations of that type and then dividing by the total number of deliberations of that type. The statistics indicate that the number of unique contributors does not significantly differ between patterns (i.e., about the same number of people participate in each generative response pattern); however, the average activity levels for a deliberation do indicate important and significant differences between patterns. The CG pattern involved the highest average number of unique contributors per deliberation and the highest average number of comments in a deliberation, indicating a significant amount of energy devoted to these longer deliberations by many contributors. In contrast, in the JS pattern, we found a relatively small number of individuals each of who individually made significantly more comments. Thus, unlike CG, in which many contributors engage in raising objections to ideas for new content, JS deliberations proceed with frequent input from a small number of contributors. Finally, for the DF pattern, we found the highest average number of deliberations per contributor, indicating some contributors actively engage in more deliberations over time than in other deliberations.

4.2. Distribution of Generative Responses over Time

Having identified the existence and key differences of three generative patterns, we then examined the distribution of the generative patterns over time. We plotted each deliberation according to when it occurred during quarterly periods from December 2001 to December 2010. We superimposed the three disruptive events: promotion 1 at the end of Q3 2005, demotion at the end of Q4 2006, and promotion 2 at the end of Q3 2007. These disruptive events divided the production cycle into four periods, which we examined to determine the generative response pattern frequency. The results are shown in Figure 3.

Figure 3 reveals that the generative response patterns were not evenly distributed over time. In periods 1 (before promotion 1) and 2 (immediately after promotion 1), the production process included all three of the generative response patterns, but in period 3 (after demotion), JS response patterns dominated (with some continued CG responses), and by period 4 (after promotion 2), deliberations of DF generative response patterns became the most frequent response. Figure 3 also demonstrates the impact of the three disruptive events in the article's history. In periods 1 and 2, virtually no effort is focused on shaping the content; instead, contributors continued to add and defend content without the benefit of any content organization. After the article's demotion, JS become the most frequent pattern of deliberation. After the final promotion, DF became the most frequent pattern. Therefore, there clearly appears to be an effect of time and disruptive event on which deliberations are used to coproduce the artifact. Although we are reluctant to overspeculate about why this pattern happens in the way it does in the absence of more complete evidence, it seems apparent that the nature of the

Figure 3 Distribution of Enacted Generative Responses over Time



change–retain tension evolves as the information artifact matures, requiring different generative responses at different points of coproduction. Because the nature of the change–retain tension depends on what knowledge has already been generated by the community, it seems natural that the generative responses will also evolve as the knowledge does. For instance, once the artifact had achieved recognition as a featured article, the emphasis of coproduction would naturally shift toward retaining the knowledge that has been created through DF responses. In the discussion section, we offer a more in-depth discussion of these findings.

4.3. Distribution of Contributors in Each Generative Response Pattern

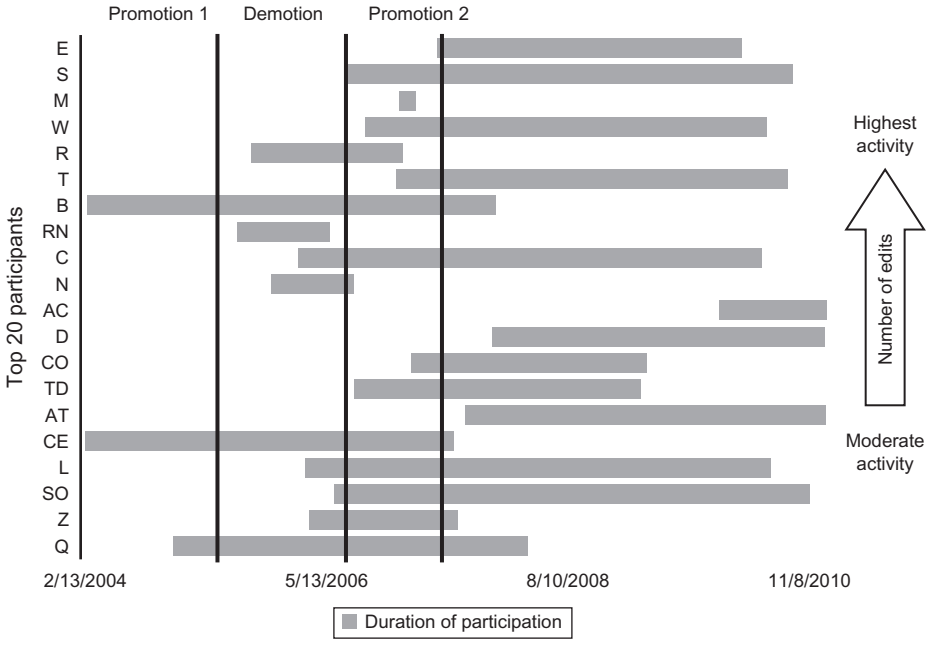
To examine if the same or different individuals applied the generative response patterns, we focused on the behavior of high-volume contributors to the 250 deliberations. To identify high-volume contributors, we first determined if those who made the most contributions to the article page were the same as those who made the most contributions to the talk page, but we found little difference between the two groups. We then examined the distribution of contributors, finding that the top 20 contributors accounted for 70% of the total comments in the 250 deliberations; the next 10 contributors added only an additional 5% of comments, and contributors below the top 30 added, at most, to 3 of the 250 deliberations. For each of these 20 high-volume contributors, we identified when their contributions started and ended. Figure 4 shows the joining and leaving activity of top contributors, demonstrating that the top contributors join and leave the community at different points in time during the production process. Plotting the discrepant events on this timeline demonstrates that some of the joining and leaving activity appears clustered around these events. From Figure 4, we observe that contributors do not each engage in the coproduction process at the same period of time.

We then examined if the top 20 contributors are equally involved in the three generative response patterns. Figure 5 displays the types of generative response patterns the top 20 contributors were involved in, with contributors grouped to cluster people with similar types of generative response patterns to aid visualization. Each contributor's activity is displayed as the percentage of his or her own activity associated with a particular deliberation pattern. Of the 20 top contributors, 10 focused more than 75% of their deliberation activity on only one deliberation pattern, 7 of the 10 focused on two patterns, and only 3 of the contributors contributing meaningfully to all three types of generative response patterns (Q, CE, and RN). It is apparent from these figures that the most frequently participating contributors do not each engage in the same set of deliberations nor do they balance their involvement in different types of generative response patterns.

4.4. Summary of Findings

We examined 250 deliberations of the knowledge change–retain tension among 3,100 contributors over the nine-year coproduction of a Wikipedia article and sought out patterns in emergent generative responses to this tension. We identified three patterns that we labeled CG, JS, and DF—each with different enacted roles and focus of deliberation. The three different patterns of generative responses arose more frequently during different points in the article's history, possibly signaled by disruptions in the article's progress. Furthermore, the different generative

Figure 4 Duration of Contribution for Top 20 Contributors

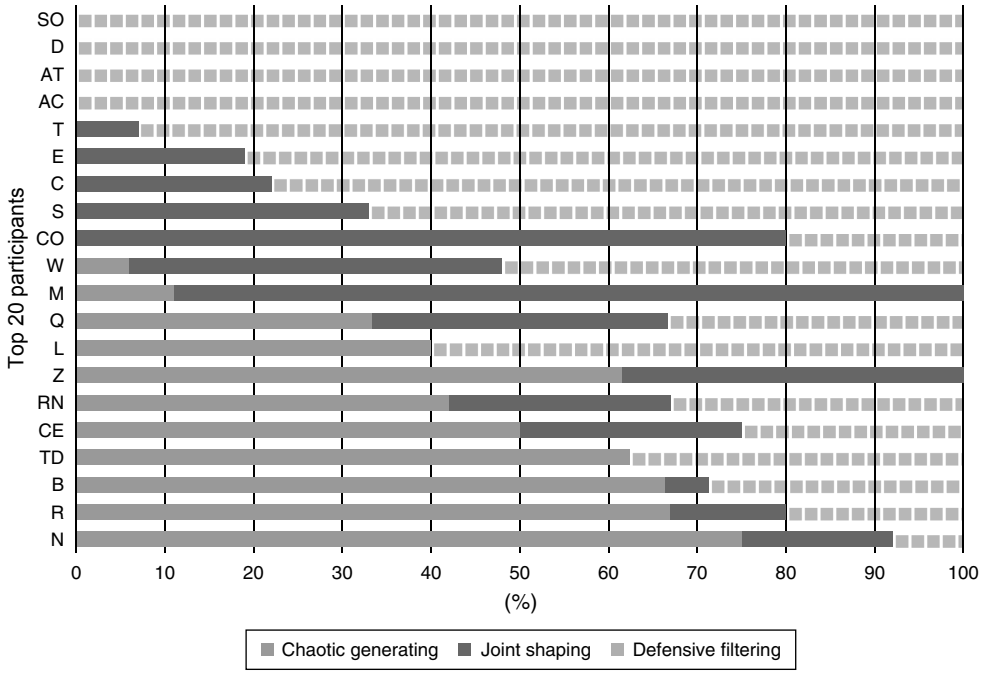


Note. Contributors' rank ordered by activity level.

response patterns involved different sets of contributors, which suggests that contributors self-selected and transiently enacted the roles they preferred.

As individuals view the artifact (or as external forces drive them), they identify a need to change the artifact in some way, raising the knowledge change–retain tension. They will then decide whether and how to participate: as a changer, retainer, or facilitator. This decision may be based on the personality and preference of each individual, the state of the deliberation at that time (e.g., is it stalled or proceeding in unsatisfactory directions), and/or external forces that suggest the need for a certain type of participation (e.g., more facilitators might be needed to

Figure 5 Contribution by Deliberation Pattern



Note. Contributors grouped by contribution type.

get agreement toward shaping to prepare for external artifact review). As the deliberations continue, eventually the deliberation is resolved and the artifact change is stabilized leading to a new state of the artifact and individuals viewing the artifact for more knowledge evolutions. Below we describe the theoretical implications of our findings, followed by practical implications and limitations.

5. Discussion

Our research question asked, How do community contributors respond to the knowledge change–retain tension to facilitate coproduction? In this study, we examined 250 deliberations concerning the knowledge change–retain tension among 3,100 contributors over the nine-year coproduction of a Wikipedia article and sought out patterns in emergent generative responses to this tension. Our examination yielded three findings. First, unlike suggestions in the literature that the emergence of community action is either prestructured or emergent, individualized, and unstructured, we find the existence of three emergent response patterns of activities characterized by different focus of coproduction and differently enacted roles that we argue help to maintain coproduction. Second, these patterns are heterogeneously distributed over the lifetime of the coproduction process such that different people engage in the different patterns at different times. Shifts in patterns correspond to disruptive events initiated from outside the community that cause shifts in the knowledge change–retain tension and concomitant shifts in responses to the tension such that different people engage in the different patterns at different times in ways that appear to be consistent with life-cycle models of more traditional software development processes (Van de Ven and Poole 1995). Third, contributors to the coproduction community tend to focus their contributions on particular patterns. Thus, instead of shifting their roles in response to change, they join and leave the community at the times when a particular pattern can be applied.

5.1. Theoretical Implications

We suggest our findings offer theoretical implications to five areas of research: (1) how the knowledge change–retain tension is resolved by the community, (2) the process by which coproduction unfolds, (3) the notion of core groups in coproduction communities, (4) the role of the artifact in fostering "community cognition," and (5) the role of disruptive events as possible signals that new roles are needed.

5.1.1. How the Knowledge Change–Retain Tension Is Resolved by a Coproduction Community. As the knowledge artifact evolves through ongoing collaboration, so does the nature of the knowledge change–retain tension associated with it. It may be less helpful to speak of a single change–retain tension than recognize multiple different manifestations of this tension over time. The community must develop different resolution strategies as the nature of the tensions evolve lest collaboration stagnate and cease being generative. Thus, the coproduction community resolves the tension by effectively identifying the nature of the change–retain tension at a given time and emergently mobilizes roles to help resolve the tension.

The three response patterns we have identified provide a way to integrate previous research that suggests either that coproduction benefits from predefined structure (e.g., O'Mahony and Ferraro 2007) or unstructured individualized emergence (e.g., Faraj et al. 2011). Our response patterns may correspond to what Faraj and Xiao (2006) refer to as emergent coordination practices by providing implicit expectations about behaviors that will facilitate the coproduction process. Contributors to the CG response pattern are participating in a process where individuals act independently to add or improve the content. Contributors to the JS response pattern are participating in a process more focused on reorganizing and improving the readability of the content rather than adding new content, and getting consensus before any changes are made. Contributors to the DF response patterns are participating in a process of improving the content of the article, but only if it can be demonstrated that the additions are demonstrable improvements and do not violate organizational and content decisions already made. Thus, these response patterns appear to become emergent coordination practices that help to guide individuals to move the production process forward, without forcing a specific structure and without being so chaotic that any guidance is missing.

The set of three patterns we have identified for resolving the knowledge change–retain tension also appears to reconcile previously disparate conceptualizations of how online coproduction communities foster coproduction. *Separately*, each of the three patterns corresponds to an approach already identified in the literature. In the CG pattern, the interaction among roles appeared to follow Hargadon and Bechky's (2006) community creativity model of help-seeking, help-giving, reflective reframing, and reinforcing found in face-to-face cocreation. The interactions among roles in the JS pattern appear to follow Kuk's (2006) strategic interaction found in open source software communities in which a few individuals engage in conversational interactivity, with what he refers to as "cross-thread connectivity." Finally, the interaction among the roles in the DF pattern follow a governance-oriented approach similar to Lee and Cole's (2003) analysis of open source

communities in which experienced and technology-enabled content retainers argue on the side of history and institutional rules are against newcomer content changers.

Our contribution, then, is not in finding each of these generative responses but rather in finding all three patterns as alternative ways to resolve the knowledge change–retain tension occurring within the same coproduction community over time. This implies that research is needed that examines not just singular patterns of interaction, such as Kuk's (2006) strategic interaction or Lee and Cole's (2003) two-tiered governance model, but rather searches for repertoires of interaction patterns. The extent to which these repertoires of patterns vary with different types of online coproduction communities warrants study. Moreover, whether the pattern repertoires are affected by external events (such as the possibility of article advancement) warrants exploration as well.

5.1.2. The Process by Which Coproduction Unfolds. These interaction patterns were not randomly distributed over time but were organized in a way that abstractly conforms to a knowledge production life cycle witnessed in more planned production efforts. These interaction patterns could be equivalent to the early idea-generation phase of a coproduction process, the integrative/shaping pattern could be equivalent to the solution selection phase, and the DF pattern could be equivalent to the incremental improvements or execution phase (Kuhn 1962, Van de Ven and Poole 1995). Given the highly fluid nature of the 3,100 contributors, the lengthy nine-year coproduction process, the lack of a formal production development process, and the contributor variation in enacting the roles, this conformance of our patterns at an abstract level to a production life cycle surprised us.

Although the generative response patterns we identified follow a rationale similar to a production life cycle, we also observed notable characteristics that differ from what has been previously reported in the literature. One noteworthy characteristic was the relatively long duration of the DF phase. Unlike a production life cycle and more similar to theories of scientific development in societies (Kuhn 1962), the third phase never appears to end. The fluid nature of the contributors means that new people will begin deliberations regarding whether to change existing knowledge no matter how long the artifact has been stabilized. These new deliberations are not only unavoidable, but required because they ensure that the knowledge is updated with new ideas, methods, and knowledge. However, determining which new knowledge to incorporate takes effort. Thus, coproduction communities need to ensure adequate effort can be devoted to this filtering process, apparently forever. Although considerable attention has been paid to the development of valuable knowledge in coproduction communities, little attention has been paid to the need to maintain this knowledge (Ransbotham and Kane 2011). This lack of attention appears disproportionate to the relative prevalence of the types of deliberations faced by online coproduction communities.

Another noteworthy characteristic of this life cycle was the parallelism we observed during the CG pattern. That is, instead of the community working on the same content topic to obtain agreement before moving to the next topic, the process was much more parallel, with many different content areas being developed simultaneously by different people. Yet, this parallelism was not enacted throughout the entire life cycle. This parallelism was shut down (literally) during the integrative process to ensure that all pieces could be brought together into a coherent artifact, but limited and controlled by the content retainers in the DF pattern to ensure that the coherent artifact was maintained. This parallelism, we believe, is essential early on in a production process to develop interest in the online coproduction process because it allows contributors to pursue their passions (Faraj et al. 2011) without being restrained by a core group defining the process or the content of the discussion. Yet, it is clear that it also must be limited at certain points of development for successful production. Thus, it is important to recognize that characteristics essential to effective production during one stage of development may actually be detrimental at another.

5.1.3. The Notion of a Core Group in Online Coproduction Communities. Contributors to the production process appear to change in response to these different interaction patterns, such that some contributors leave and join the production process at different points in time, with a preference for engaging in certain types of involvement over others. It is difficult to speculate regarding the causal mechanisms of this observation. Do contributors leave and join because the interaction patterns change? Or do the interaction patterns change because the contributors leave and join? Regardless, it appears that rather than a core group of the same individuals changing their roles in the community, a small group of 10–20 individuals appear to have preferred roles. This observation suggests that models such as the core-peripheral apprenticeship program (Lave and Wenger 1991, 2002) used by some online production researchers (e.g., Preece and Shneiderman 2009) may not apply in all online coproduction communities or at all stages of production. These core-periphery models of community membership suggest a stable core

group of contributors gradually identifies and mentors peripheral contributors to become members of the core group. We found no evidence of such mentoring processes during the deliberations and that,while there appeared to be a small number of active contributors, these contributors did not start or end at the same time nor change roles in response to changing production focus. Thus, with online coproduction communities, the notion of a core group may need to be replaced with notions of selectively frequent contributors who choose to participate primarily when they can enact roles in a way that is consistent with their preferred response pattern. How these contributors can be identified and leveraged to encourage a continued production process is an important research topic.

Contributors joining and leaving the community in response to the developmental stage of the community also has implications for our understanding of why people contribute in these open coproduction communities. Substantial research on online community contribution has focused extensively on a wealth of motivating factors, including incentives (e.g., Roberts et al. 2006), group norms (e.g., Baggozzi and Dholakia 2006), expertise (Wasko and Faraj 2005), and time commitment (Butler et al. 2002). Our findings suggest that an individual's motivation to contribute may depend on the mix of one's preferred response pattern and the stage of a community's production development. Thus, future research on online coproduction should take the developmental state of the knowledge of the community into account in explaining why people contribute to the coproduction process.

5.1.4. Role of the Artifact in Fostering "Community Cognition." How and why the shifts occur between patterns of generative responses is theoretically important. We suggest that these shifts are made possible because the nature of the artifact seems to allow for a process similar to heedful interrelating (Bechky 2006, Hargadon and Bechky 2006, Weick 1998), consistent with explanations of community cognition. The artifact allowed for heedful interrelating in the sense that the artifact provided the stability and visible routines (e.g., word usage, talk page separated from article change, and promotions of articles) needed for individuals to exert the continued effort to maintain a community cognition (Weick and Roberts 1993). Changes to the artifact also fostered changes in the focus of the community cognition, in a similar manner to how the focus of production changed. For the CG deliberations, for example, community cognition focused on the accuracy of information being posted to the article; for the JS deliberations, the community cognition focused on reorganizing the artifact for better readability; and for the DF deliberations, community cognition focused on updating the article only as needed.

These different focuses of community cognition that are embodied, coalesced, and coordinated by the artifact, and its evolution suggests that future research should examine this role of the artifact in more detail. Furthermore, given that the changes in the artifact puts temporal limitations on these heedful interactions, there are likely critical relationships as the focus evolves, such that there may be overlaps, seepage, or signals to indicate when the interaction is changing and how. The role of both the artifact and the technology in which the artifact is embodied (e.g., historical information conveyed on a talk page) warrants further study.

We drew upon the symbolic boundary literature to illustrate "conceptual distinctions made by social actors to categorize objects, people, and practices" (Lamont and Molnar 2002, p. 168) that offer "conditions for separation and exclusion, but also for communication, exchange, bridging and inclusion" (p. 181). Our findings suggest that these evolving community cognitions within a community may be not only dynamic but generatively so; without these differences between production focus, for example, the role of a facilitator is not uniquely applied, and the shift from one unique application of the facilitator to another does not get signaled, creating delays in the production process. Thus, our study suggests the value of considering such factors as within-community boundary salience, permeability, and boundary shift trajectories over time in understanding how online coproduction communities handle their ongoing tensions.

5.1.5. Disruptive Events. Although a community cognition focus on the generative response patterns explains how contributors interact within each stage, it is also important to discuss the implications of why these community cognitions change. In our study, the critical junctures entailed highly visible external feedback ratings, with well-documented interpretations and explanations:[7] the article was or was not promoted, and the article was or was not demoted. Perhaps the highly visible and clearly interpretable nature of the feedback served as a "simple structure" (Okhuysen and Eisenhardt 2002) that signaled the need for a shift in governance, much like the midpoint in a project serves to signal to project members that they should reconsider the path to the outcome (Gersick 1991).

In this case, shared cognition about how to interpret and respond to the specific event may not be

[7] http://en.wikipedia.org/wiki/Wikipedia:Featured_article_candidates/Autism (accessed February 27, 2014).

needed if there is already a common understanding (Clarke et al. 2006) of the implications of the event for the group's action (Fiol 1994). The evolution of a coproduction community may be fostered by contributors' abilities to adjust their governance processes to external episodic feedback, similar to Tyre and Orlikowski's (1994) windows of opportunity model or the Majchrzak et al. (2000) discrepant events model. According to these models, governance and production seemingly should proceed along a stable pattern until a discrepant event suggests the need for reevaluation and consideration of a different path. Discrepant events models receive support in team settings (Gersick 1991, Majchrzak et al. 2000, Okhuysen and Eisenhardt 2002, Orlikowski et al. 1995), but they have not been demonstrated previously in online communities.

Moreover, discrepant events models assume shared cognitive processing of the discrepant event; in the autism production process, the lack of temporal overlap across contributors performing different enacted roles calls into question the existence of shared cognition about the discrepant event. In the absence of shared cognition, it may be the information artifact itself that serves as the coordination mechanism for the community's stages. The disruptive event (e.g., promotion, demotion) draws attention to the state of the information artifact. If contributors participating in a particular stage share a collective cognition, these disruptive events may trigger awareness that their current collective cognition is inadequate to accomplish the production goals, requiring a shift in roles and cognition. The contributors who can and are willing to shift roles in response to these disruptive events may do so, although those contributors who have neither the ability nor interest leave the community and make room for new contributors.

Similarly, these disruptive events visibly displayed on the information artifact may also attract the attention of individuals outside of the coproduction community who assess the state of the artifact and determine whether they are willing and able to play the roles required by the coproduction community. A newly promoted article may attract those who are interested in protecting the valuable content, although the newly demoted article may attract those who are interested in reshaping the article to improve its value. Implications are that coproduction community researchers may need to account for the state of the information artifact in their understanding of the interactions in coproduction communities. To our knowledge, there is no research that has integrated the current state of the information artifact into an understanding of how online coproduction communities operate. Such external feedback mechanisms could provide an alternative means of governing certain types of online production communities, as opposed to more formal and direct governance structures (e.g., O'Mahony and Ferraro 2007).

5.2. Management Implications

Our findings have a number of important implications for online coproduction communities or for organizations that seek to cultivate or work with online coproduction communities. First, the recognition of the evolving nature of coproduction communities discourages a one size fits all approach to online communities. As organizations seek to cultivate and support online coproduction communities from inside (i.e., providing leadership) or outside (i.e., providing resources), they should recognize that the needs of the community will differ at different stages, which will require different types of support at different stages. For example, studies that argue for the importance of shaping behavior (e.g., Majchrzak et al. 2013) may be wrong if the production process is only in the idea generation phase. Thus, an awareness of the current state of the coproduction community, likely reflected in the current state of the information artifact, may be essential to cultivating effective online coproduction communities.

Furthermore, as organizations or community leaders seek to motivate contributors, they need to recognize not only that contributors may be motivated differently from one another, but also these differences may be associated with the stage of development. Malone et al. (2009) break down contributors' various motivations into three types—money, love, and glory. One could imagine each of these different motivations being more prevalent among contributors in different types of interaction patterns. Those participating in chaotic generating may be motivated by love of the topic, those participating in joint shaping may be motivated by the glory of shaping a high-quality article, although the less enjoyable and glamorous tasks of defensive filtering may be best supported by people with a vested interest in maintaining its quality. Regardless, recognizing that contributors may be motivated differently at different stages will be important for those seeking to cultivate robust coproduction communities. In short, what made it possible for a community to coproduce an artifact thus far may not be sufficient for improving the artifact further.

Finally, much of the online community literature focuses on contributor retention as an important goal. Our findings suggest that not only might contributor retention not be desirable at all times in the evolution of the community, but also it may actually be detrimental. Contributor retention may prevent new individuals from entering the community, playing new roles, and allowing the community to move to the next stage of development. Community

leaders should recognize that the people who contributed to get the community to one stage of production may not be the same people who are most valuable for the next stage. Online communities may need to realize that previously valuable contributors may need to leave for the community for the coproduction to evolve.

5.3. Limitations

This key role of the knowledge artifact in coordinating roles and boundaries raises important concerns regarding the generalizability of our findings. Open source software and Wikipedia communities have a mission to create stable knowledge artifacts, with vision statements, norms, and formal reviews of the artifacts resulting from the deliberations as well as hierarchical management structures establishing larger boundaries within which the knowledge change–retain tension is played out. Thus, the existence of a production life cycle may be limited to coproduction communities where there is an implicit agreement that the desired outcome of the coproduction process is a stable knowledge artifact, or the emergent coordination practices we observed might be limited to coproduction communities that are hierarchical. Not all coproduction communities may share the same vision on outcomes, and some communities may only exist to share ideas and not collectively move past the idea generation phase. Therefore, to have predictable emergent coordination response patterns for deliberations may require some agreements made at the hierarchical level about the purpose of the community's coproduction effort. Thus, although we do not think our findings are necessarily limited to Wikipedia or wiki-based coproduction communities, they may be limited to communities that are focused on collaboratively developing knowledge artifacts. Further research is needed to assess the generalizability of our findings.

6. Conclusion

In the process of coproducing a Wikipedia article, a repeatable set of generative responses—comprising a collection of roles, shifting production focus, and identifiable patterns of interaction—characterized the resolution of the tension between knowledge change and knowledge retention. The appearance of all three generative responses in a single online coproduction community suggests that the various types of contributor interaction in previous research on online coproduction communities may exist to varying degrees in all online coproduction communities. Therefore, as researchers of online coproduction communities, we must be cautious in generalizing about the patterns of behaviors we believe we are observing because the patterns of generative responses we find may be more temporary than we realize. Our findings suggest a value in theories of online communities moving away from identifying specific generative responses to understand how communities productively shift across responses over time. Response shifts may not always satisfy all parties, but it permits the community of fluctuating contributors to remain energized and willing to attend to the next input, the next knowledge change, and the next deliberation. Our findings reveal dynamism and negotiated emergence throughout this the process.

Acknowledgments

The authors thank department editor Sandra Slaughter and her review team for constructive comments on an earlier version of the paper. The authors also thank Lily Chen for help with coding, and the National Science Foundation [Grants 1219832, 0953285] for generous funding of this research.

References

Alavi M, Leidner DE (2001) Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues. *MIS Quart.* 25(1):107–136.

Argote L, McEvily B, Reagans R (2003) Managing knowledge in organizations: An integrative framework and review of emerging themes. *Management Sci.* 49(4):571–582.

Bagozzi RP, Dholakia UM (2006) Open source software user communities: A study of participation in Linux user groups. *Management Sci.* 52(7):1099–1115.

Bechky BA (2006) Gaffers, gofers, and grips: Role-based coordination in temporary organizations. *Organ. Sci.* 17(1):3–21.

Boland RJ, Tenkasi RV (1995) Perspective making and perspective taking in communities of knowing. *Organ. Sci.* 6(4):350–372.

Bryant SL, Forte A, Bruckman A (2005) Becoming Wikipedian: Transformation of participation in a collaborative online encyclopedia. *Proc. 2005 Internat. ACM SIGGROUP Conf. Supporting Group Work* (ACM, New York), 1–10.

Butler B, Joyce E, Pike J (2008) Don't look now, but we've created a bureaucracy: The nature and roles of policies and rules in Wikipedia. *Proc. SIGCHI Conf. Human Factors Comput. Systems* (ACM, New York), 1101–1110.

Butler B, Sproull L, Kiesler S, Kraut R (2002) Community effort in online groups: Who does the work and why? Weisband S, ed. *Leadership at a Distance* (Lawrence Erlbaum Associates, New York), 171–194.

Butler BS (2001) Membership size, communication activity, and sustainability: A resource-based model of online social structures. *Inform. Systems Res.* 12(4):346–362.

Chambres P, Auxiette C, Vansingle C, Gil S (2008) Adult attitudes toward behaviors of a six-year-old boy with autism. *J. Autism Dev. Disord.* 38(7):1320–1327.

Clarke J, Thorpe R, Anderson L, Gold J (2006) It's all action, it's all learning: Action learning in SMEs. *J. Eur. Indust. Training* 30(6):441–455.

Dansereau F, Graen G, Haga WJ (1975) A vertical dyad linkage approach to leadership within formal organizations: A longitudinal investigation of the role making process. *Organ. Behav. Human Performance* 13(1):46–78.

Dholakia UM, Bagozzi RP, Pearo LK (2004) A social influence model of consumer participation in network-and small-group-based virtual communities. *Internat. J. Res. Marketing* 21(3): 241–263.

Dixon GN, Clarke CE (2013) Heightening uncertainty around certain science: Media coverage, false balance, and the autism-vaccine controversy. *Sci. Comm.* 35(3):358–382

Edsall JT, Bearman D (1979) Historical records of scientific activity: The survey of sources for the history of biochemistry and molecular biology. *Proc. Amer. Philos. Soc.* 123(5):279–292.

Faraj S, Xiao Y (2006) Coordination in fast-response organizations. *Management Sci.* 52(8):1155–1169.

Faraj S, Jarvenpaa SL, Majchrzak A (2011) Knowledge collaboration in online communities. *Organ. Sci.* 22(5):1224–1239.

Fiol CM (1994) Consensus, diversity, and learning in organizations. *Organ. Sci.* 5(3):403–420.

Forte A, Bruckman A (2005) Why do people write for Wikipedia? Incentives to contribute to open-content publishing. *GROUP 2005 Workshop—Sustaining Community: The Role and Design of Incentive Mechanisms in Online Systems* (ACM, New York), 6–9.

Forte A, Larco V, Bruckman A (2009) Decentralization in Wikipedia governance. *J. Management Inform. Systems* 26(1):49–72.

Fulk J, Flanagin AJ, Kalman ME, Monge PR, Ryan T (1996) Connective and communal public goods in interactive communication systems. *Comm. Theory* 6(1):60–87.

Gersick CJ (1991) Revolutionary change theories: A multilevel exploration of the punctuated equilibrium paradigm. *Acad. Management Rev.* 16(1):10–36.

Glaser BG, Strauss AL (1967) *The Discovery of Grounded Theory; Strategies for Qualitative Research* (Aldine Publishing, Chicago).

Goffman E (1961) *Asylums*: *Essays on the Social Situation of Mental Patients and Other Inmates* (Anchor Books, Garden City, NY).

Hargadon AB, Bechky BA (2006) When collections of creatives become creative collectives: A field study of problem solving at work. *Organ. Sci.* 17(4):484–500.

Heidgerken AD, Geffken G, Modi A, Frakey L (2005) A survey of autism knowledge in a health care setting. *J. Autism Dev. Disord.* 35(3):323–330.

Jehn KA, Northcraft GB, Neale MA (1999) Why differences make a difference: A field study of diversity, conflict and performance in workgroups. *Admin. Sci. Quart.* 44(4):741–763.

Jeppesen LB, Frederiksen L (2006) Why do users contribute to firm-hosted user communities? The case of computer-controlled music instruments. *Organ. Sci.* 17(1):45–63.

Kalman ME, Monge P, Fulk J, Heino R (2002) Motivations to resolve communication dilemmas in database-mediated collaboration. *Comm. Res.* 29(2):125–154.

Kane GC (2011) A multimethod study of information quality in wiki collaboration. *ACM Trans. Management Inform. Systems* (*TMIS*) 2(1):Article 4.

Kane GC, Alavi M (2007) Information technology and organizational learning: An investigation of exploration and exploitation processes. *Organ. Sci.* 18(5):796–812.

Kane GC, Fichman RG (2009) The shoemaker's children: Using wikis for information systems teaching, research, and publication. *MIS Quart.* 33(1):1–17.

Kane GC, Fichman RG, Gallaugher J, Glaser J (2009) Community relations 2.0. *Harvard Bus. Rev.* 87(11):45–50.

Kim HK, Bateman B (2010) Student participation patterns in online discussion: Incorporating constructivist discussion into online courses. *Internat. J. E-Learn.* 9(1):79–98.

Kittur A, Kraut RE (2010) Beyond Wikipedia: Coordination and conflict in online production groups. *Proc. 2010 ACM Conf. Comput. Supported Cooperative Work* (ACM, New York), 215–224.

Kudaravalli S, Faraj S (2008) The structure of collaboration in electronic networks. *J. Assoc. Inform. Systems* 9(10/11):706–726.

Kuhn TS (1962) *The Structure of Scientific Revolutions* (University of Chicago Press, Chicago).

Kuk G (2006) Strategic interaction and knowledge sharing in the KDE developer mailing list. *Management Sci.* 52(7):1031–1042.

Lakhani KR, Von Hippel E (2003) How open source software works: "Free" user-to-user assistance. *Res. Policy* 32(6):923–943.

Lamont M, Molnar V (2002) The study of boundaries in the social sciences. *Annual Rev. Sociol.* 28(1):167–195.

Lave J, Wenger E (1991) *Situated Learning: Legitimate Peripheral Participation* (Cambridge University Press, Cambridge, UK).

Lave J, Wenger E (2002) Legitimate peripheral participation in communities of practice. *Supporting Lifelong Learn.* 1:111–126.

Lee GK, Cole RE (2003) From a firm-based to a community-based model of knowledge creation: The case of the Linux kernel development. *Organ. Sci.* 14(6):633–649.

Majchrzak A, Wagner C, Yates D (2013) The impact of shaping on knowledge reuse for organizational improvement with wikis. *MIS Quart.* 37(2):455–469.

Majchrzak A, Rice RE, Malhotra A, King N, Ba S (2000) Technology adaption: The case of a computer-supported inter-organizational virtual team 1. *MIS Quart.* 24(4):569–600.

Malone T, Laubacher R, Dellarocas C (2009) Harnessing crowds: Mapping the genome of collective intelligence. Research Paper 4732-09, MIT Sloan School of Management, Cambridge, MA.

March JG (1991) Exploration and exploitation in organizational learning. *Organ. Sci.* 2(1):71–87.

Marwell G, Oliver P (1993) *The Critical Mass in Collective Action* (Cambridge University Press, Cambridge, UK).

Monge PR, Fulk J, Kalman ME, Flanagin AJ, Parnassa C, Rumsey S (1998) Production of collective action in alliance-based interorganizational communication and information systems. *Organ. Sci.* 9(3):411–433.

Nov O (2007) What motivates Wikipedians? *Comm. ACM* 50(11): 60–64.

Okhuysen GA, Eisenhardt KM (2002) Integrating knowledge in groups: How formal interventions enable flexibility. *Organ. Sci.* 13(4):370–386.

O'Mahony S, Ferraro F (2007) The emergence of governance in an open source community. *Acad. Management J.* 50(5): 1079–1106.

Orlikowski WJ, Yates J, Okamura K, Fujimoto M (1995) Shaping electronic communication—The metastructuring of technology in the context of use. *Organ. Sci.* 6(4):423–444.

Pava CH (1983) *Managing New Office Technology: An Organizational Strategy* (Simon and Schuster, New York).

Preece J, Shneiderman B (2009) The reader-to-leader framework: Motivating technology-mediated social participation. *AIS Trans. Human-Comput. Interaction* 1(1):13–32.

Rafaeli S, Hayat T, Ariel Y (2005) Wikipedia community: Users' motivations and knowledge building. *Cyberculture 3rd Global Conf., Prague, Czech Republic*.

Ransbotham S, Kane GC (2011) Membership turnover and collaboration success in online communities: Explaining rises and falls from grace in Wikipedia. *MIS Quart.* 35(3):613–627.

Ransbotham S, Kane GC, Lurie N (2012) Network characteristics and the value of collaborative user-generated content. *Marketing Sci.* 31(1):387–405.

Ren Y, Kraut R, Kiesler S (2007) Applying common identity and bond theory to design of online communities. *Organ. Stud.* 28(3):377–408.

Roberts JA, Hann IH, Slaughter SA (2006) Understanding the motivations, participation, and performance of open source software developers: A longitudinal study of the Apache projects. *Management Sci.* 52(7):984–999.

Stewart KJ, Gosain S (2006) The impact of ideology on effectiveness in open source software development teams. *MIS Quart.* 30(2):291–314.

Strauss AL, Corbin JM (1990) *Basics of Qualitative Research*: *Grounded Theory Procedures and Techniques* (Sage Publications, Newbury Park, CA).

Tyre MJ, Orlikowski WJ (1994) Windows of opportunity: Temporal patterns of technological adaptation in organizations. *Organ. Sci.* 5(1):98–118.

Van de Ven AH, Poole MS (1995) Explaining development and change in organizations. *Acad. Management Rev.* 20(3):510–540.

Wagner C (2004) Wiki: A technology for conversational knowledge management and group collaboration. *Comm. Assoc. Inform. Systems* 13(19):265–289.

Wasko MM, Faraj S (2005) Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. *MIS Quart.* 29(1):35–57.

Weick KE (1998) Introductory essay—Improvisation as a mindset for organizational analysis. *Organ. Sci.* 9(5):543–555.

Weick KE, Roberts KH (1993) Collective mind in organizations: Heedful interrelating on flight decks. *Admin. Sci. Quart.* 38(3): 357–381.

Wolff S (2004) The history of autism. *Eur. Child Adolesc. Psychiatry* 13(4):201–208.

Yates D, Wagner C, Majchrzak A (2010) Factors affecting shapers of organizational wikis. *J. Amer. Soc. Inform. Sc. Tech.* 61(3): 543–554.

Zellmer-Bruhn ME (2003) Interruptive events and team knowledge acquisition. *Management Sci.* 49(4):514–528.