Life-cycle Changes in Modes of Coordination in Wikipedia Articles

We present evidence of explicit and non-explicit coordination (i.e., coordination mediated or not by discussion) in the context of Wikipedia. Using a novel approach to identifying edits to the same part of a Wikipedia article, we show that a majority of edits in a small sample of articles are not associated with discussion on the article Talk page. However, we find that explicit coordination seems related to article quality. Analyzing different modes of coordination over the articles' life cycle, we show that explicit coordination seems to follow non-explicit in higher quality articles.

CCS Concepts: • **Human-centered computing** → **Collaborative content creation**; **Wikis**; **Empirical studies in collaborative and social computing**; Social network analysis;

Additional Key Words and Phrases: coordination, stigmergy, distributed groups, Wikipedia, on-line epistemic community

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1 INTRODUCTION

In this paper, we examine different modes of coordination in virtual groups, with particular attention to the possibility of coordination that is achieved without discussion (i.e., non-explicit coordination). We examine this question in an open organization, Wikipedia, in which we can observe the relationship between explicit and non-explicit coordination and the quality of the resulting work.

By achieving coordination in Wikipedia, we mean how editors can manage the dependencies between their activities [26] as they collaboratively but independently contribute to articles. A particular focus is how editors determine where to edit given other's contributions. This definition of coordination, as managing dependencies between activities, is consistent with the large body of literature developed in the field of organization theory (building on classics such as [15, 25, 37]) that emphasizes the importance of interdependence in group work.

Theories of group coordination suggest a basic distinction between explicit and implicit coordination. Explicit coordination covers cases where individuals explicitly communicate about their actions or planned actions to identify and manage dependencies. In contrast, theories of implicit coordination (e.g., [33]) suggest that team members can predict and adjust behaviors without communication.

We propose an approach to disentangle the different modes of coordination in order to assess their respective importance during different phases of the virtual construction of a piece of knowledge. The goal of this paper is thus to study in the case of online working groups when explicit coordination is needed, and when non-explicit coordination is used. The question we address is not so much as is it possible to coordinate without explicit communication, but rather the volume of

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non-explicit coordination and the relation between modes of coordinating and the overall quality of the output.

2 THEORY

To guide our examination of coordination in Wikipedia, we draw first on coordination theory [26]. We extend our theorizing about different modes of coordination by drawing on [8] regarding the distinction between articulation work, awareness, and stigmergy.

Coordination theory [26] analyzes group action in terms of actors performing interdependent tasks to achieve some goal, where the tasks require or create shared resources thus creating interdependencies among the tasks. The key point is that the dependencies create problems or potential synergies that require additional work to manage. Malone and Crowston [26] called the tasks embodying this extra work "coordination mechanisms", making a distinction between the tasks and the mechanisms needed to coordinate the tasks. These two concepts are sometimes labelled "work" versus "articulation work" [16, 36].

In explicit coordination, the coordination mechanisms involve communication among the actors regarding the work. Much of the focus of research on supporting coordination has addressed ways to improve explicit coordination. For example, an early CSCW system, the "Coordinator", sought to improve coordination by making communication more explicit about the coordination required [14, 43].

Researchers have also identified the possibility of implicit coordination, in which members of a team can determine what needs to be done and how to do it even in the absence of explicit communication, e.g., by sharing well-developed mental models of how the other team members work [3, 42], how a task has to be realized or team situation models [33]. In other words, people's background knowledge may allow them to engage in interdependent tasks without explicit communication. In this case, the information needed for the coordination mechanisms comes from the actor's own prior knowledge.

However, the reliance on shared mental models poses limits on the viability of implicit coordination. For example, in self-organized groups, there is no formal authority to impose a particular way of working. Distributed groups may lack face-to-face meetings at which to develop shared understandings, which poses particular challenges for coordination. More effort is required for interaction when participants are distant and unfamiliar with each others' work [28, 34]. Watson-Manheim et al. [41] suggested that distributed work is characterized by numerous discontinuities, that is, a lack of coherence in some aspects of the work setting (e.g., organizational membership, business function, task, language or culture) that hinders members trying to make sense of the task and communication with others [39], or that produces unintended information filtering [12] or misunderstandings [1]. These interpretative difficulties, in turn, make it hard for group members to develop the shared mental models necessary for implicit coordination [10, 13]. In open projects such as Wikipedia in particular, as entry and exit are free, contributors may vary in level of experience and in knowledge (or mental models) of how the project works.

More recently, researchers have suggested a third possibility for coordination, suggesting that work can be coordinated through the outcome of the work itself [2, 5, 8, 35], a mode of coordination analogous to the biological process of stigmergy [17]. Heylighen defines stigmergy thusly: "A process is stigmergic if the work... done by one agent provides a stimulus ('stigma') that entices other agents to continue the job" [20]. Accordingly, stigmergic coordination can be defined as coordination (i.e., management of dependencies among tasks and resources) based on signals from the shared work rather than on shared understandings or explicit communication. Stigmergic coordination is thus non-explicit without being implicit.

While stigmergy was formulated to explain the behavior of social insects following simple behavioral rules, it has also been invoked to explain classes of human behaviors: the formation of trails in a field as people follow paths laid down by others (similar to ant trails), or markets, as buyers and sellers interact through price signals [30]. For humans and intelligent systems, the signs and processing can be more sophisticated than is found for insects [32]. For example, the shared environment can be a complex workspace including annotations. Tummolini and Castelfranchi [38] developed a typology of different kinds of messages possible from signs, such as having the ability to do something, having done something or having a goal. In the CSCW literature, Christensen [5, 6, 7, 8] explicit how architects and builders coordinate their tasks through "the material field of work" such as drawings. Stigmergy has also been used to explain coordination in open source software development [2, 20].

Stigmergy is particularly relevant for technology-supported teams. In particular, when work products are shared via a computer system, team participants can see the artefacts produced by remote colleagues as easily as those from local colleagues [11] and these artefacts can provide information to support team coordination.

Stigmergy can be readily interpreted in the coordination theory framework mentioned above. Malone and Crowston [26] describe coordination mechanisms as relying on other necessary group functions, including decision making, communications, and development of shared understandings and collective sense making [4, 9]. The stigmergic approach suggests that the "shared material" itself can be a communications medium, allowing coordination without recourse to separate coordinative mechanisms [7]. Christensen observed this type of coordination among architects, noting that their work is:

> "partly coordinated directly through the material field of work.... [I]n addition to relying on second order coordinative efforts (at meetings, over the phone, in emails, in schedules, etc.), actors coordinate and integrate their cooperative efforts by acting directly on the physical traces of work previously accomplished by themselves or others" [8].

While the concept of stigmergy focuses on signals from the work itself, it may be that the work products include additional information that provides cues for coordination. According to [18, 19], awareness occurs when actors complete their work including other signals that are sent to a targeted audience, without requiring that an answer must be given. These authors and [8] stress the fact that co-location is needed for this process, as the signal is more often a physical one (e.g., body posture, sounds). The key concept is that this signal is broadcast, but can be seen or understood only by specific people. In virtual communities, for example, awareness could be supported by using specific, by-invitation channels to accompany work products with an explanation or a description of the work done.

In summary, the literature on coordination suggests that coordinating a set of interdependent tasks requires additional work that has its own needs for information. The information needed to coordinate may come from different sources, ranging from explicit discussions to signals from the work or included with the work to the actor's own inherent stocks of knowledge. In our analyses in this paper, we group these sources in two, distinguishing between explicit and non-explicit (i.e., stigmergic or implicit) coordination. Our goal in this paper is to discuss the respective weight of explicit and non-explicit coordination in the case of an open, virtual project, Wikipedia and to examine how these different sources are related to the quality of the resulting work product.

3 COORDINATION IN WIKIPEDIA

We choose Wikipedia as a venue for studying how coordination is achieved for several reasons. First, Wikipedia is a prominent example of on-line epistemic community, in which many editors contribute to a collaborative output. Any user can contribute and edit the content of the articles, allowing us to examine group interactions in an uncontrolled setting, where the nature of coordination is emergent rather than dictated.

Second, the desire to create a coherent article means that there are dependencies between the editing tasks that each editor undertakes: knowing where and what to contribute and connecting individual contributions into a whole. As a result, coordination among editors is required for a quality output [21, 23]. However, coordination is expected to be particularly difficult for Wikipedia editors, as they are dispersed all over the world with limited opportunities for interaction and they are diverse with different backgrounds, knowledge and expertise.

Third, studying Wikipedia is convenient, as all editing on the articles is done via the Wikimedia platform that records essentially all editing and social interaction for each article. As well, there are formal guidelines and mechanisms for assigning quality ratings to Wikipedia articles, allowing researchers to have a somewhat objective measurement of group performance outcomes.

In the Wikipedia setting, the main tasks undertaken by members of the group are edits to articles. Editors can explicitly coordinate with each other (e.g., about where to edit or about content or style) via the article Talk page, a dedicated page associated with each article that provides a forum for coordinating changes to the article, prioritizing additions, discussing policies and procedures and eliciting assistance from other editors. Empirical studies in Wikipedia coordination have generally explored explicit coordination (e.g., [22–24, 31, 40]).

Editors can also work in parallel without explicitly coordinating. For example, editors may share a vision of what an article should cover that guides their decisions about coverage, perhaps based on earlier discussions, earlier collaboration, or a common point of view, and without any needed phase of dialogue regarding what has to be done (i.e., implicit coordination).

Finally, as the editors share a common work space (the article), there are possibilities for awareness and for stigmergic coordination, where the edits made by one editor spark edits made by another, complementing or repealing what has been done. The Wikipedia infrastructure provides direct support for coordination based only on the following-up of an edit. To facilitate tracking modifications and edits, the Wikimedia systems enables a logged-in user to set a watchlist. A watchlist is a page that generates a list of recent changes made to the pages being watched. In this way, an editor can keep track of what's happening to these pages and so react to these changes.

As well, when editors make a modification (an edit), they have the possibility to leave a comment to explain why the modifications were made. This information is available in the history of the page. This comment can be considered as a message sent to explain or drive new work, and thus as generating awareness. The frontier between awareness and stigmergic coordinations, in this case, is quite blurred. If we consider awareness based on its historical definition that requires co-presence, it is nearly impossible outside specific Wikipedia hackathon events. However, in a more general sense, it may be that editors are signalling each other through other channels.

In summary, in Wikipedia a change can impel consecutive changes following or not a discussion in the talk pages. We identify as non-explicit coordination cases in which one editor's edit is made in response to another editor's edit rather than in response to explicit discussion.

4 METHOD

The over-all design of the study presented in this article is comparative case study. We describe the pattern of editing observed in articles of different quality levels to determine the extent to which

coordination appears to be done with or without discussion. Specifically, we selected 2 articles each from 3 quality levels, from featured article (FA) to good article (GA) to C-level article (i.e., one still lacking important content). The articles were selected from the English-language version of Wikipedia, as it has the largest number of articles and the software we used was originally developed to process this version. Within each article we examine the nature of coordination and its evolution over time. Through this examination, we arrive at the relation between these two modes of coordination and article quality.

4.1 Evidence of non-explicit coordination in Wikipedia

In this section, we describe how we analyzed Wikipedia edits for evidence of explicit and non-explicit coordination.

The work done in Wikipedia is recorded in the revision history of a Wikipedia page. The revision history shows nearly every version of the article (in extremely rare cases, a revision can be deleted, e.g., if an edit added libelous content), with a time stamp (date and time of creation), the most recent editor (or IP address for anonymous edits), an optional flag for minor changes applied by the editor, the size of the changes (in bytes) and an optional comment given by the editor (see Figure 1). We call these items the revision metadata, as opposed to the textual content of each article revision.

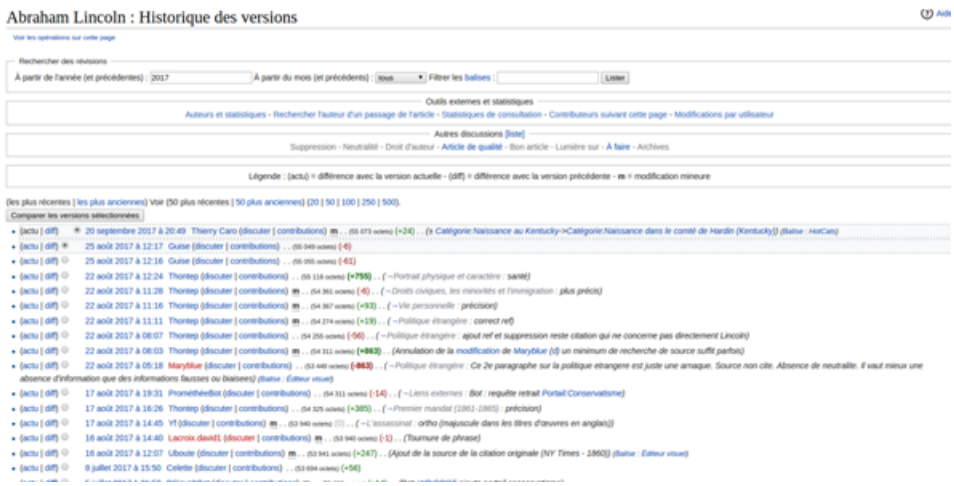


Fig. 1. Example of revision page in Wikipedia

The changes between pairs of revisions can be accessed through so-called diff pages. Diff pages display a line-by-line comparison of the wiki markup text of two revisions (see figure 2). The diff page for a pair of chronologically adjacent revisions *rev-1* and *rev-2* thus displays the editing activity of one editor at a certain point in time in the history of a page. We call the changes from one revision to another a diff.

By looking for diffs that changed the same lines of the articles, we can distinguish cases where two editors contributed to the same part of an article versus editors making changes in unrelated sections of an article. (Note that a line in a Wikipedia article is more like a paragraph in a word processing document, as it may span multiple lines when displayed on the screen.) This approach is an advance over simply connecting editors who have edited the same article, without considering if these edits are at all related.

Fig. 2. Difference between two versions of an article: A diff

For each Wikipedia page, there is a corresponding Talk page, which provides a forum for editors to discuss possible changes to an articles. The Talk page is itself a wiki page, so by examining diffs for this page, we can identify individual contributions to this discussion. These discussions are evidence of the possibility of explicit coordination.

We identify as possible cases of non-explicit coordination consecutive edits made to the same line of the article by two editors who do not similarly interact in the discussion on the article Talk page. Such a situation suggests that the second editor's actions were prompted by the first editor's edits rather than by explicit discussion.

4.2 Non-explicit edit network structure

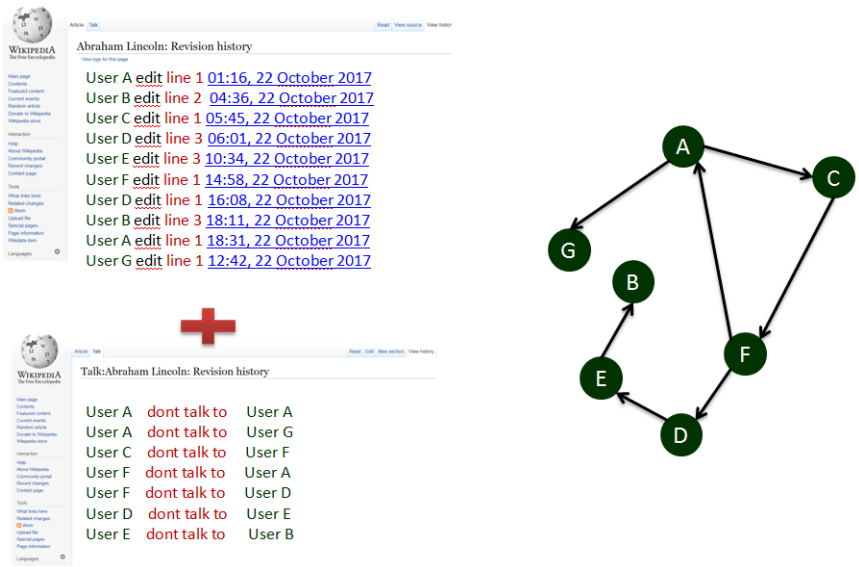


Fig. 3. An example of non-explicit editing network of a wikipedia article

We represent the way one editor's edits might influence another editor's edits in the form of a social network. A social network is a graph comprising nodes representing individuals or organizations and edges between pairs of nodes representing some kind of relationship between the nodes. In our case, the nodes in the network represent the editors who have contributed to the article. We dropped bots (i.e., programs that automatically make edits) from consideration. We added an edge from editor B to editor A when B edits a line in an article that was last edited by A

(loops are allowed when an editor edits the same line repeatedly). This process created an oriented graph. We call this network the *Edit* network. The presence of a edge from B to A means that A's contribution may have influenced B's. The count of the edges added represents how often B edited following A. A similar network was created for edits on the Talk page (a *Talk* network). In this network, the count of the edges from B to A represents the number of times editor B replied to a contribution to the Talk page by A.

Fig. 4. Assessing edit quality in Wikipedia using ORES scores

Table 1. Cooperation quality

Editor 2		Editor 1		
		Damaging	**Good faith**	
			Minor	**Not minor**
Damaging		Vandalism (V)		
Good faith	**minor**	Minor fixes (MF)		
	not minor	Repairing vandalism (RV)	Own contribution (OC)	Interesting cooperation (IC)

Finally, we form a network of non-explicit edits by considering only edges in the *Edit* network where B never replied to editor A on article Talk page or B replied to editor A only after editing the text (i.e., we remove from the *Edit* network the *Talk* network and we add edges where editors talk but after the action (edge of *Edit* network)). Contrariwise, the intersection between the *Edit* network and the *Talk* network represents edits made by editors who have also communicated at some point in the creation of the article. An instance of the process of constructing the networks is shown in Figure 3. We note that this is an overly strict operationalization, since the discussion on Talk might not have been related to the edits, but it provides a first estimate, which may be refined in future versions.

4.3 Contribution quality and coordination

We are interested in how an edit by one editor might prompt action by another, with, or without the need for explicit discussion. We note though that there can be several kinds of prompts. It could be that the second editor is reacting to evidence of vandalism by the first or simply fixing small errors (e.g., typos or grammar). In both these cases, it would not be surprising to see a second editor make an edit without always feeling the need to explicitly coordinate with another (even if in the case of vandalism, an edit can follow a dispute in the talk pages, too). And of course, it might be that the second edit is itself vandalism, rather than a response to the first edit. While the editing decision in both cases can be considered coordination, we are most interested in situations where both editors are making substantive additions to the article. Therefore, the second step of the coding was to identify the nature of each edit to assess the kind of cooperation between the editors.

To identify cooperation quality, we assess the quality of each edit using the web service ORES (Objective Revision Evaluation Service[1]), which generates a score of edit quality as shown in Figure 4. According to this score, it is possible to classify edits into damaging or good-faith edits. We also consider the scale of the edit as declared by the editor's use of the "minor edit" flag (applied when "only superficial differences exist between the current and previous versions"[2]). Based on these classifications, we identify five type of contributions, as shown in Table 1 (referring to the type of the second edit).

(1) Vandalism (V) is defined as a damaging edit after any other edit.
(2) A minor fix (MF) is when the second contribution is good faith but minor edit after any other edit.
    The interesting situations are when the second contribution is a non-minor good faith edit.
(3) Coming after a damaging edit, we consider this some kind of repair of vandalism (RV).
(4) After a minor edit, the editor's own contribution to the article (OC)
(5) And finally, a non-minor edit after another non-minor edit represents an interesting level of cooperation (IC) between the editors, each in turn making a substantive contribution to the same part of an article.

4.4 Data collection and analysis

We used the Wikipedia API to collect the data for our study because it provides precise information about the edits that can be easily connected to other data, such as the edit quality from ORES score. We wrote a program to extract data using the API and to parse the revision history for each article and the associated Talk page to identify the individual edits. For each edit, the program retrieved the edit quality from the ORES Web service. Finally, the program built the *Edit* and *Talk* networks by identifying the consecutive edits made in the same line. To analyze the network structure, we used the Python package Networkx.

5 RESULTS

In this section, we present our results: first detailed descriptive statistics of explicit and non-explicit coordination for two sample articles, showing the importance of the non-explicit coordination for both minor and major contributions, before looking at the evolution of the different modes of coordination over the life time of all six articles of various quality from the English Wikipedia.

[1] http://ores.wmflabs.org/
[2] https://en.wikipedia.org/wiki/Help:Minor_edit

5.1 Importance of non-explicit coordination

As noted above, editors may be triggered to edit without explicit coordination by both positive and negative changes to an article. To understand the nature of the collaboration, we sorted the edits for two example articles into the five categories defined in Table 1. As a comparison, we did the same for explicit edits, those for which there was also a contribution to the article's Talk page (computed as the intersection of the *Edit* and *Talk* networks).

Table 2. Descriptive statistics of different network properties of Abraham Lincoln

	edit	talk	explicit	non-explicit
#nodes	4600	1787	71	4600
#relations	19534	6790	2443	17091
density	0.00119	0.0028	0.058	0.00118

Table 3. Descriptive statistics of different network properties of Business

	edit	talk	explicit	non-explicit
#nodes	2444	72	0	2444
#relations	5248	87	0	5248
density	0.0015	0.030	0.0	0.0149

Table 4. Descriptive statistics for collaboration quality

	Abraham Lincoln		Business	
	Non-explicit	explicit	Non-explicit	explicit
#Contributions	17091	2443	5248	0
Vandalism (V)	3185	16	2089	0
Repair Vandalism (RV)	2452	4	1437	0
Minor Fixes (MF)	4058	578	697	0
Own contribution (OC)	2305	220	336	0
Interesting Cooperation (IC)	5091	1625	689	0

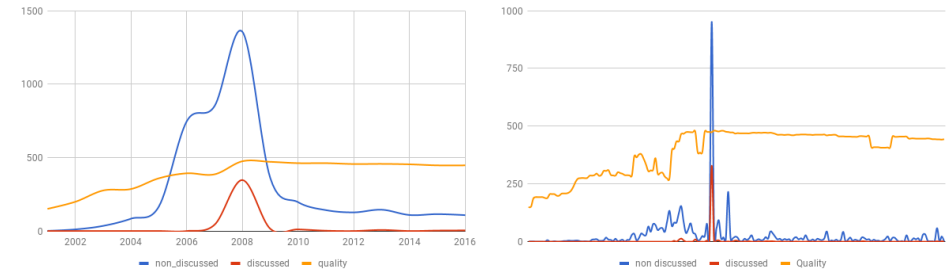
Tables 2 and 3 give descriptive statistics for the different networks created for two of the articles (Abraham Lincoln, GA and Business, C-level) as examples of the results of the data analysis process.

Table 4 gives the counts of the edits in the different categories. About 4/5ths of contribution to the *Abraham Lincoln* article are done without discussion (non-explicit); the remaining 1/5th are made with contribution to the Talk page (explicit). In contrast, all of the edits to the Business article were made without discussion. We also see a much higher fraction of damaging edits and fixes, which may reflect a lower rate of non-minor good-faith contributions.

Unsurprisingly, nearly all edits in both articles classified as Vandalism or Repairing Vandalism are made without discussion. It is not surprising that those making damaging edits do not discuss their plans on Talk. However, it seems that to repair vandalism, editors also intervene in a stigmergic way.

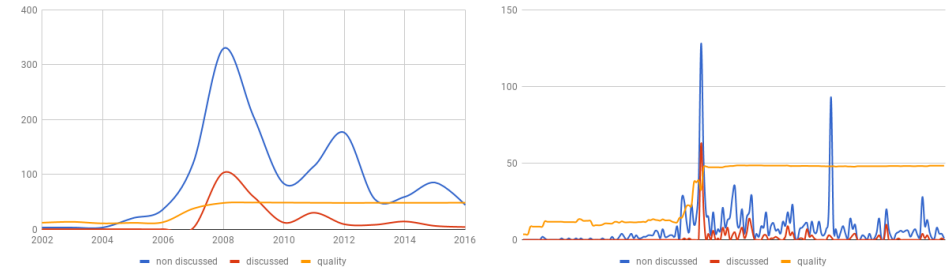
5.2 Evolution of explicit and non-explicit coordination

In this section, we examine how the mode of coordination of articles evolved over the life of the articles. For this analysis, we focus on cases where both editors contribution effectively to the article, the situations we labelled as interesting cooperation, own contribution and minor fixes. Accordingly, the remainder of this analysis examines only those cases, omitting vandalism and repairs. To emphasize the comparison between explicit and non-explicit coordination, we sum together the three included categories.



(a) yearly evolution of coordination mode in Ant article

(b) Monthly evolution of coordination mode in Ant article



(c) yearly evolution of coordination mode in Augustine of Canterbury article

(d) Monthly evolution of coordination mode in Augustine of Canterbury article

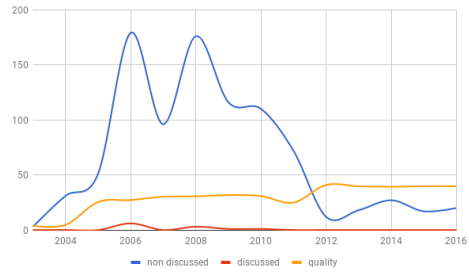
Fig. 5. Evolution of coordination mode of two FA articles.

Figures 5, 6 and 7 show the volume of explicit and non-explicit edits over time (summed yearly and monthly) for two articles from each quality level.

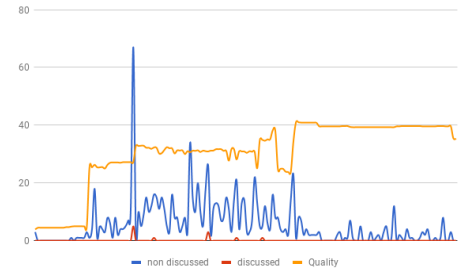
A first observation is that the initial growth of the articles in all cases seems to happen without discussion. These results suggests that editors start the article making substantive additions without needing to discuss.

For the higher quality articles, there appears to be a second phase of development. In a second phase, the editors may understand that the article need more efficient work according to the current quality or they have to agree on specific activities to reach the main levels of qualities. The increased amount of cooperation in a explicit way suggested that discussion on Talk is guiding such non-minor contributions. However, pattern in the the Glass Fiber article suggests that even a small amount of discussion may be sufficient.

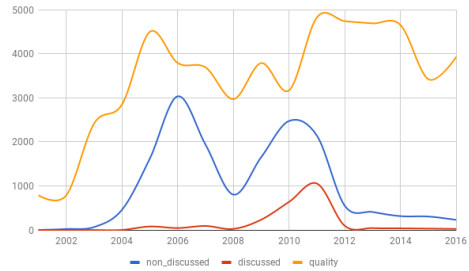
In contrast, for the C class articles, we find a noticeably different distribution of cooperation quality. Strikingly, nearly all contributions are done in a non-explicit mode, without discussion



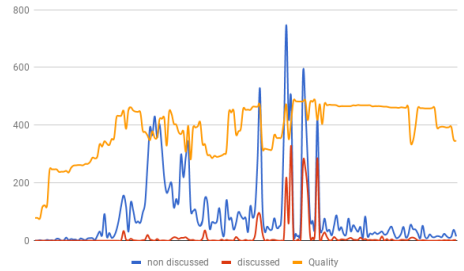
(a) Yearly evolution of coordination mode in Glass Fiber article



(b) Monthly evolution of coordination mode in Glass Fiber article



(c) Yearly evolution of coordination mode in Abraham Lincoln article



(d) Monthly evolution of coordination mode in Abraham Lincoln article

Fig. 6. Evolution of coordination mode of two GA articles.

on Talk. Contrary to FA and GA articles, editors in C class do not communicate to improve their situation, which may explain why they article remains at the lower quality level.

Finally, once the article reach a certain level of quality all the effort (explicit and non-explicit) decreases.

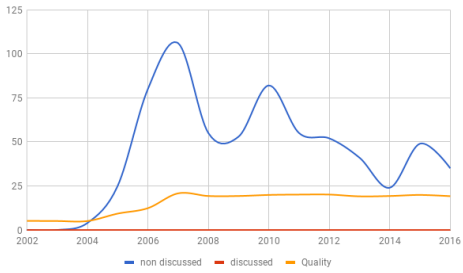
Overall, comparing the cooperation effort in different article class, we see much less non-stigmergic editing, suggesting that discussion plays an important role in improving the quality of an article.

6 CONCLUSION

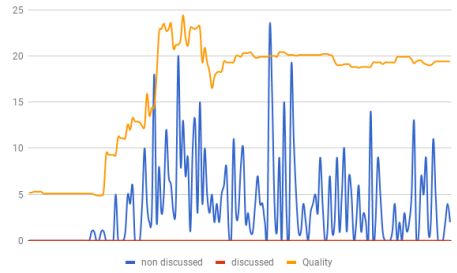
In summary, the data presented in this paper suggest that a substantial fraction of the edits made on Wikipedia are coordinated without explicit discussion on the Talk pages. We hypothesize that these edits represent stigmergic coordination, namely, the prior edit itself sparks the following action.

It is not very surprising that “minor fixes” and “repairing vandalism” are mostly stigmergic, as the edit itself contains the information of what is to be done. Indeed many of these tasks have been automated (edit bots).

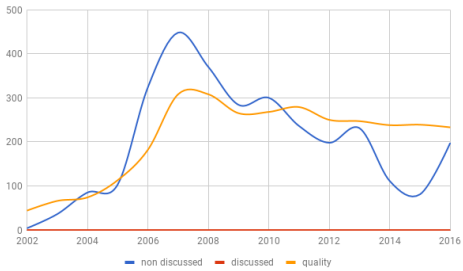
More surprising is that even more substantive contributions seem often to be made without the need for discussion, and that, at least for the randomly selected articles we studied, non-explicit coordination not only precedes explicit coordination, but even allows to reach a high level of quality for the article. The difference between articles of poor quality and articles of high quality is more



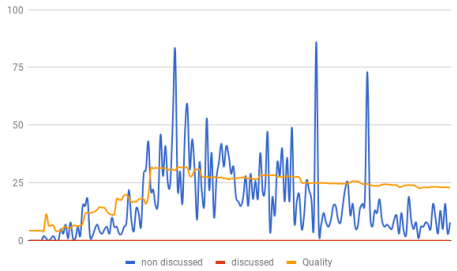
(a) Yearly evolution of coordination mode in Alphabet Song article



(b) Monthly evolution of coordination mode in Alphabet Song article



(c) Yearly evolution of coordination mode in Business article



(d) monthly evolution of coordination mode in Business article

Fig. 7. Evolution of coordination mode of two C class articles.

than the volume of edits (something already known, see [29]), but actually, and more surprising, of non-explicitly coordinated edits.

However, discussion matters, apparently either to fix disagreement (avoiding a stigmergic-edit war), or to reach the ultimate levels of quality (the GA-FA level), and to organize the "freezing" of an article of quality (as, after a phase of explicit edits, the volume of edits seems to drop).

These results thus elaborate the findings of [21], about the three phases of a Wikipedia article: there is a "Chaotic Generating" phase, which is mostly stigmergic, a "Joint Shaping" phase, which starts with a explicit editing period, and "Defensive Filtering" phase, which is mostly stigmergic and of lower intensity than the first two.

6.1 Contributions

This paper contributes to research on coordination and on Wikipedia. Methodologically, the paper proposes a more refined approach to relating the contributions of Wikipedia editors by tracking edits line-by-line rather than article by article. We argue that this approach to building a network is a better reflection of how the work of one editor might influence another.

Theoretically, the paper demonstrates the potentially important role that stigmergy and awareness play in coordinating the work of members of a distributed group. The data show how stigmergic coordination can support both for fixing problems and for making substantive contributions to the article.

6.2 Future research

Our results suggest multiple opportunities for further research.

First, our analysis has examined only six articles in a qualitative fashion, grouping together the different kinds of edits. Gathering data on a larger sample of articles would enable us to test the relationship between different patterns of editing and article quality over time.

Our analysis has considered only the metadata for edits and only coordination of allocation of effort. Examining the content of the edits, while much more challenging, could yield more insight into how the distributed group of Wikipedia editors achieve coordination in creating quality articles.

More work is needed to understand how editors interpret the signals from the Wikimedia system regarding the activities of others and use those as guides for their own contributions, thus enabling stigmergic coordination. The share of these stigmergic coordination events which are in fact awareness coordination (edits with a joined comment which is aimed at triggering reaction from a targeted audience) remains matter of investigation.

While our current analysis rules out explicit coordination of most edits, it is not sufficient to distinguish between implicit and stigmergic coordination. It could be that editors find the Talk discussions useful in guiding their own behaviors without having to contribute themselves, a sort of peripheral participation (though this mode of working is itself a form of stigmergic coordination). To establish the source of the information used by editors to coordinate will require more interaction with the editors.

Of particular interest is whether this kind of coordination helps novice editors. On many occasions, editors have discussions on the Talk pages or ask how to make contributions, thus improving through interaction with experienced editors. Passive reading of the Talk pages, or the history pages may provide a form of social learning. From such interactions, new editors can learn discipline and the rules and regulations about Wikipedia. [27] similarly described how citizen scientists learned from proxies of practice recorded in discussions.

However, in communities like Wikipedia where participation is open, editors are not obliged to discuss for learning, and a newcomer may not know the existence of these artifacts. It is easier to learn directly by observing edits and by practicing. If they do not face difficulties and need help from other editors, they can directly contribute and making their own decision by following others.

Finally, coordination has been a perennial topic in CSCW research. Researchers and system developers may seek to examine or support in other settings the modes of non-explicit coordination examined in this work.

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