"It Feels Better Than Filing": Everyday Work Experiences in an Activity-Based Computing System

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ABSTRACT

Activity-based computing represents an alternative to the dominant application- and document-centric model at the foundation of most mainstream desktop computing interfaces. In this paper, we present in-depth results from an *in situ*, longitudinal study of an activity-based computing system, Giornata. We detail the ways that the specific features of this system influenced the everyday work experiences of a small cohort of knowledge workers. Our analysis provides contributions at several levels of granularity—we provide concrete design recommendations based on participants' reactions to the particular features of the Giornata system and a discussion about how our findings can provide insight about the broader understanding of knowledge work and activity within HCI.

Author Keywords

Activity-based computing, knowledge work, deployment study, multitasking, tagging, collaboration, Giornata.

ACM Classification Keywords

H5.2 [Information interfaces and presentation (e.g., HCI)]: User Interfaces—Graphical user interfaces.

INTRODUCTION

Activity-based computing represents an increasingly explored alternative to the dominant application- and document-centric model at the foundation of most mainstream desktop computing interfaces. As an emergent paradigm, activity-based computing seeks to foreground computational representations of activities in the design of interfaces to provide functionality that aligns more closely with the ways that knowledge workers think about and manage their work in the real world. This paradigm is based on observational studies of how knowledge workers utilize representations of activities to manage multiple tasks [1, 5, 8, 17, 22], manipulate information [3, 4, 13, 16], and

collaborate effectively with colleagues or clients [5, 8, 26]. Many ongoing research programs have sought to understand the role of activity in a variety of computing environments, ranging from software engineering firms [8] to hospital wards [2]. It is anticipated that as activity-based systems are adopted more widely, they will provide a variety of benefits, including better task awareness, simpler multitasking, more natural organization of electronic information, and improved online collaboration.
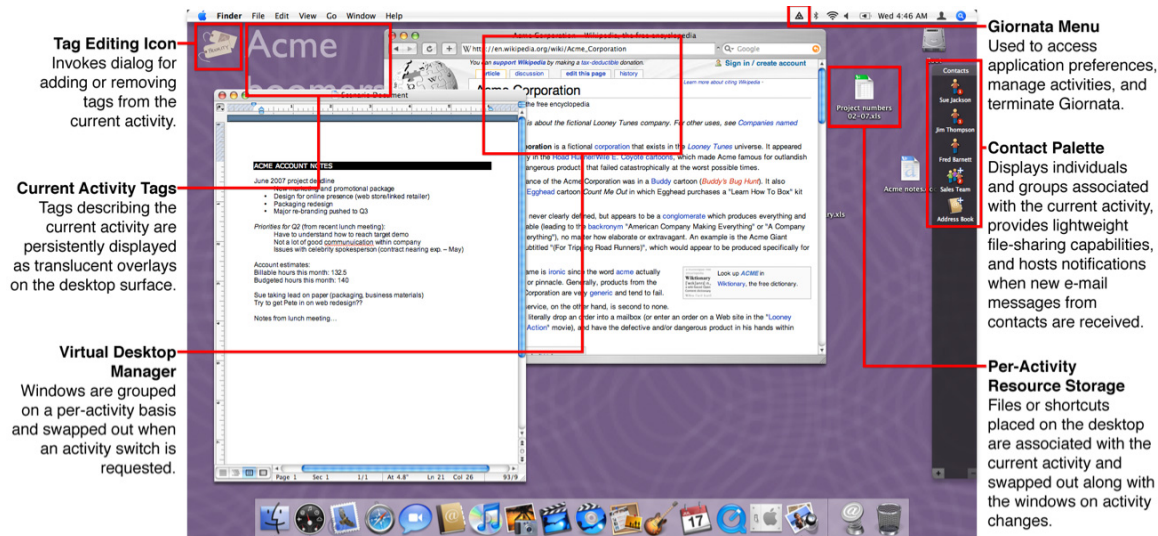
Although a number of activity-based prototypes have been developed [2, 6, 9, 10, 15, 18, 20, 21, 24], relatively few have been deployed and evaluated in the context of real-world use. A few key exceptions include Bardram's use of the ABC framework in several design workshops in Danish hospitals [2], Muller et al.'s 100-day study of the collaborative tools provided by ActivityExplorer [18], and small, limited-duration deployments of the UMEA [10] and GroupBar systems [21]. The research community will need to undertake more extensive studies of how knowledge workers appropriate activity-based tools to accomplish their tasks and of how these tools influence knowledge work, itself, in order to better understand the practical implications of applying the activity-based interaction paradigm to a new generation of interfaces.

A central aim of this research is to better understand the potential for activity-based tools to enable, shape—or possibly hinder—knowledge work. Empirical studies have shown that knowledge work is exceptionally individualized and that diversity, both in work practices and deliverables, is one of its hallmarks [12]. The intellectual labor involved in making sense of and transforming information requires an intimate familiarity with one's own information organization strategies and the tools available at hand for manipulating the information. Additionally, meaning-making takes place evolutionarily and over time.

Evaluating an activity-based tool in a controlled environment would limit the diversity of information, organization, and tools that participants could draw upon and would only allow us to elicit participants' impressions about the software's usefulness after—at most—an hour or two of usage. Because imposing these constraints would change some of the fundamental characteristics of knowledge work and potentially mask the effects of

Tag Editing Icon
Invokes dialog for adding or removing tags from the current activity.

Current Activity Tags
Tags describing the current activity are persistently displayed as translucent overlays on the desktop surface.

Virtual Desktop Manager
Windows are grouped on a per-activity basis and swapped out when an activity switch is requested.

Giornata Menu
Used to access application preferences, manage activities, and terminate Giornata.

Contact Palette
Displays individuals and groups associated with the current activity, provides lightweight file-sharing capabilities, and hosts notifications when new e-mail messages from contacts are received.

Per-Activity Resource Storage
Files or shortcuts placed on the desktop are associated with the current activity and swapped out along with the windows on activity changes.

Figure 1. The Giornata prototype's interface, as deployed in the study. Callouts indicate particularly salient features of the system.

introducing activity-based tools, we elected instead to conduct a longitudinal study exploring how activity-based tools are adopted and utilized in real-world, authentic work environments and in the broader context of existing knowledge work artifacts. Designing, implementing, and deploying a full-featured, activity-based computing system that fundamentally re-frames the desktop environment for all computing tasks required significant engineering efforts. We were fortunate to recruit a small cohort of knowledge workers willing to tolerate the daily inconvenience of a new—and not always robust—working environment as they shifted their real-world computing tasks from the traditional application- and document-oriented desktop to our experimental activity-based desktop system.

In this paper, we present the detailed findings from this deployment of the Giornata system. We present quantitative results gleaned from surveys and log data collected by the Giornata software during an average of two months of use as well as qualitative results from semi-structured interviews carried out at multiple points during the study. Taken together, these findings contribute novel empirical evidence about how knowledge workers appropriate activity-based computing technologies in the context of their own work practices.

Many of Giornata's features were directly influenced by observations about the ways that knowledge workers interact with computers (e.g., [1, 3, 4, 5, 8, 17, 26]) and theories about the ways that humans cognitively process and manage activities (e.g., [7, 11, 14, 25]). In this paper, we draw attention to a number of insights that stem from instantiating these observations and theories into a concrete design. Even our small cohort showed a tremendous amount of diversity in information management practices and one key success factor in the system design was its ability to support this diversity. Allowing users to orchestrate work as activities enabled very lightweight knowledge work practices, such as organizing files into

activity "piles," creating holding areas for emergent activities, and using activities as informal reminders. Longer-term challenges include helping individuals manage dormant activities and the documents associated with them as well as facilitating activity-based collaboration. Overall, our analysis provides contributions at several levels of granularity—we provide both concrete design recommendations based on participants' reactions to the particular features of the Giornata system and a discussion about how our findings can provide insight about the broader understanding of knowledge work and activity within the domain of HCI.

RESEARCH DESIGN
Deployed System Details
We provided our participants with a fully functional version of Giornata, an activity-based system designed for Mac computers running the OS X operating system (Figure 1). When Giornata is running, the computer provides a unique virtual desktop for each ongoing work activity; all electronic work takes place within one of these activities. Each activity's virtual desktop provides storage for the windows, digital artifacts, and iconic representations of the colleagues associated with that activity. Using a menu bar icon or a keyboard shortcut, it is possible to quickly switch between open activity representations; create new, empty activity desktops; or remove unneeded virtual desktops and archive their contents to a regular folder when activities are completed. Each activity's desktop can also be tagged, providing a source of semantically meaningful metadata to annotate all of the digital artifacts associated with the activity. Although details about the design of the Giornata system have been published elsewhere [24], we provide a brief summary of its key features here.

Support for Managing Multiple Simultaneous Activities
Like other activity-based systems (e.g., Rooms [9] and GroupBar [21]), Giornata allows individuals to view and

manipulate open windows in clusters that correspond to higher-level activities, since accomplishing one task often requires the use of information resources spanning multiple applications and documents [1, 5, 8, 17]. However, Giornata goes beyond rudimentary virtual desktop management by providing activity-based resource storage, a flexible tagging system that allows individuals to incrementally annotate activities with meaningful descriptors, and integrated tools to foster collaboration within ongoing activities.

Activity-Based Resource Storage

In Giornata, the enhanced desktop serves not only as a display space for application windows, but also as an active, easily accessible folder for documents and shortcuts associated with the current activity. Any files saved to the desktop (by dragging them onto the desktop or invoking the standard "save" menu item within applications) are automatically associated with the current activity; as an individual switches among ongoing activities, these resources are "swapped out" along with application windows and temporarily stored elsewhere on disk until the activity is resumed. This combination of capabilities scopes the information displayed on the screen at any time to those applications, information resources, contacts, and awareness cues relevant to the current activity.

Activity and Information Resource Tagging

Each activity created in Giornata can be annotated with optional, freeform tags to describe the semantics of the activity. Activities are initially created without tags; the ability to create and work in an unnamed activity allows work to proceed even when the significance or eventual meaning of an activity is not known at its outset.

When an activity has one or more tags associated with it, these tags are transferred to each file that is touched over the course of working in that activity. This design serves to "stamp" files with information about the context in which they were created or edited. This feature also allows documents that are shared across multiple activities to "inherit" the tags of all the activities. Because OS X's built-in search framework indexes these tags automatically, individuals can quickly find information resources by searching based on the files' contents or the activity tags.

Activity-Based Collaboration Support

Giornata provides several features to support activity-aware collaboration. The system integrates a subset of the sharing palette interface [23] to enable lightweight collaboration. This "Contact Palette" component provides a persistent visual summary of those individuals and groups who have been explicitly associated with the current activity. Files can be dropped directly on Contact Palette icons to share a file (via e-mail) with a particular contact or group.

Because the primary goal of the study was to understand how people would adopt and appropriate an activity-based system in the course of everyday knowledge work, we opted to focus on ensuring that the core activity-centric features of the system were as stable as possible for the long-term, *in situ* evaluation. As a result, we disabled some of the system's more complex collaboration features (e.g., a continuously-updated, peer-to-peer "sharing space" region on the desktop; see [24] for details) for the study deployment.

Procedure

Participants were given a demonstration of the features of the Giornata system and asked to use it for several months in the course of their day-to-day work. Participation in the study required a substantive commitment since we were asking participants to carry out all of their computer-based work for the duration of the study within the context of the Giornata prototype. The average duration of participation in the study was 54 days (max = 82 days; min = 22 days); a few participants elected to continue using the system long after the completion of the study.

For the deployment, Giornata was instrumented to log information about when the system was started or terminated, when activities were created or removed, when activity tags were changed, and when switches between activities occurred. After approximately three weeks of system use, we conducted midpoint semi-structured interviews with each of the participants to elicit feedback about their experiences using the software and to learn about the ways that Giornata was and was not matching their particular work practices. After the midpoint interviews, participants were given the option to discontinue using Giornata. A final set of summative interviews were carried out approximately two months later to elicit feedback about whether the participants had continued to use the software or had resorted to previous multitasking and task management tools. We also asked questions designed to uncover whether Giornata might or might not have affected the longer-term organizational strategies used by the participants. Within the context of these final interviews, we orally administered surveys comprising a small number of Likert-style questions to elicit participants' general impressions of the system.

Participants

Our participant population was comprised of a small cohort of Mac users—two university faculty members (F1 and F2), two graduate students (G1 and G2), and one industrial HCI practitioner (H1)—recruited using snowball sampling through our research-based social network. The only requirements for participating in the study were that individuals use a Mac computer running OS X, version 10.4.8 or later, and have the authority to install software on the computer. Participants were not compensated for their participation.

Due to the somewhat fragile nature of the Giornata research software, the length of time we were asking our participants to commit to using the system, and the need for us to provide consistent and responsive technical support for the

duration of the software deployment, we intentionally recruited a small cohort of participants to study in detail. However, in order to increase the generalizability of our results and elicit feedback grounded in a variety of knowledge work practices, we selected an organizationally diverse set of participants. Although the study design was not focused on observing collaboration among the participants, we did aim to include a number of participants in the study who regularly worked together, with the hope that we might be able to triangulate among multiple individuals' perspectives on shared projects in the data.

All participants completed all portions of the study design except for H1, who was unable to schedule a summative interview at the conclusion of the study. Another participant (F1) also served as a pilot participant for this research—providing feedback on both the software and the interview protocols as they were being developed.

RESULTS
Based on the Likert-style survey questions, our participants reported having generally positive experiences using the system. When asked to rate the system on its usefulness using a 5-point Likert scale (1 = "not at all useful," 5 = "very useful"), the average response was 4.2[1]. When asked to rate how well the system allowed them to organize and manage activities without interrupting their work and how well the system helped them to manage and organize their information, the responses were also generally positive, with average ratings of 4.2 and 4.0, respectively. The survey question that garnered the least positive response asked participants to rate how well the system helped them to collaborate with their colleagues; the average rating for this question was 3.4. While this was not, strictly speaking, negative feedback, we will present some of the possible reasons for the lukewarm response later as we unpack the results from our qualitative interviews.

Logged Use of Giornata
Based on the log data captured by the Giornata system, the participants' usage patterns confirmed some success in adopting an activity-centered interaction model. The participants maintained an average of 7.6 "open" activities on their systems over the course of the study (Figure 2) and switched between activities an average of 28.2 times per day on days that the system was used at all (ranging from participant G2's average of 4.4 switches per day to participant F2's average of 48.2 switches per day).

Some participants maintained longer lists of more finely specified activities (e.g., F1, with an average of 13.8 open activities); others created only a few, high-level activities (e.g., G1 and G2, each with an average of 4.2 open
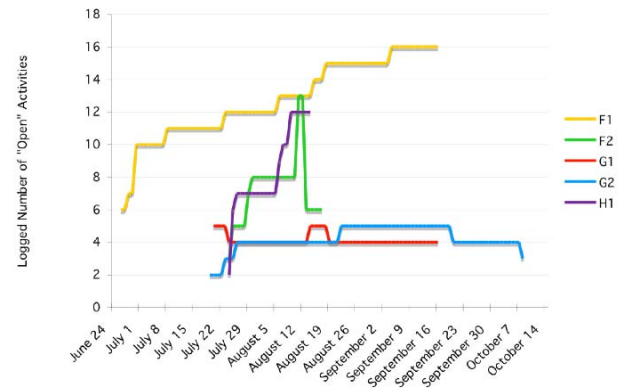
Figure 2. The number of "open" activities logged at the end of each day during the Giornata deployment.

activities). This variability in the granularity of participant-specified activities replicates previous findings [19] and demonstrates Giornata's flexibility to suit a wide range of work practices. In fact, we observed several distinct work styles reflected in Giornata's log data, including:
- maintaining a relatively long, detailed list of ongoing activities, but only switching infrequently among a subset of them on a day-to-day basis (F1);
- creating just a few activities to group work at a high level and switching among them very frequently (G1); and
- utilizing a short list of high-level activities, but carrying out all work within one or two of these activities each day (G2).

There was no correlation (in either direction) between an individual's average number of open activities and the average number of activity switches they made each day.

Participants generally tagged activities using one or two words (mean = 1.8 words, standard deviation = 1.122), and, in most cases, assigned these tags to their activities immediately upon creation. Two participants provided at least one tag for every activity they created; the other three participants maintained at least one untagged activity for the entire duration of the study (see Table 1). The tags used to initially describe activities proved to be quite stable; there were only 12 instances in which tags were added to or removed from an activity during the entire study (H1 changed activity tags eight times; G2, twice; and F1 and F2, once each). Finally, the participants generally used tags to label activities descriptively, rather than taxonomically (e.g., as a list of searchable attributes). Only one participant (F1) re-used any tags when labeling multiple activities.

Two participants used the ability to retroactively apply tags to an activity after it had existed for some time. Participant H1 used this feature repeatedly, retroactively applying tags to "label" activities associated with nascent projects with their corporate identification numbers once the projects were approved and the numbers assigned.

Interviews with the Study Participants
We interviewed the study participants twice following the deployment of Giornata. The first series of these semi-

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Types of Tags Used to Annotate Activities	Percentage of All Logged Activities Exhibiting One or More Tags of This Type
A specific project name or identifier	25.9%
The name of an organization or group	16.7%
No tags applied, "(untagged)"	14.8%
A conference or event name	13.0%
The name of a software application (excluding "email" and "e-mail")	7.4%
"Email" or "E-mail"	7.4%
A course name or identifier	5.6%
The word "personal"	5.6%
The name of a specific person	3.7%
The name of a specific place	3.7%
A date	3.7%
The words "calendar" or "scheduling"	3.7%

Table 1. The types of tags used by participants to describe their activities during the Giornata deployment.

structured interviews took place approximately 2–3 weeks into the study and each interview lasted about 30 minutes. The second set of interviews took place approximately two months after the first series of interviews; each lasted about 25 minutes. Except for the interview with participant H1, who lived and worked in another large city across the country and was interviewed using Skype[2], all interviews were conducted in person at each participant's workplace. Interview questions were grounded in the activities that participants had created and focused on participants' perceptions of and interactions with various features of the system, such as its activity-based desktop storage and the Contact Palette. All of the interviews were digitally recorded and manually indexed based on field notes taken during the interviews.

We coded the interview data against the conceptual framework that was originally used to guide the development of the Giornata software. This framework defined some key challenges for activity-based systems, which were grounded in previous empirical studies and cognitive theory: the need to fluidly integrate computational representations of activity into existing work practices, the need for representations of activity to encapsulate evolving work artifacts, and the need for representations of activity to support different facets of collaboration. Findings from the interviews that were particularly salient—both those that directly addressed the framework and those that stood out as being surprising or interesting—were coded and grouped into thematic clusters.

Managing Multiple Simultaneous Activities
The ability to maintain a flexible number of open virtual desktops was cited as a particularly valuable aspect of the

system, especially when compared to other virtual desktop implementations:

> I tended to be very lazy when I did [virtual] desktops in the past about keeping them partitioned, which means it became less useful because it was never clear where anything was. And if I'm not paying attention, that can still happen with Giornata, but I think by the notion of binding specific activities to specific [desktops] has helped with that…. It may be that there's not that fixed layout [of other virtual desktop managers]. (Participant F2)

Several participants noted that structuring their work into explicit activities provided a valuable, persistent reminder about the state of ongoing tasks. Participants F1 and H1 both discussed ways that their use of Giornata either complemented or served as a substitute for their existing information organization tools (e.g., to-do lists). Participant F1 pointed out one particular to-do function of her activities: she intentionally left several activities open in Giornata solely to serve as reminders for following up with colleagues, even though she knew that she was "not going to do any more work" in these activities. Participant G2 recognized the potential for using activities as reminders, but had difficulties visually distinguishing among open activities; he felt that stronger visual cues would have enabled better ongoing activity awareness.

Several participants spoke of activities as having distinct states, such as "active," "background," and "completed." However, even when they were no longer working in an activity, few participants took the concrete step of formally "closing" the activity in Giornata. Participant G1 reported closing several activities (in an attempt to tidy his activity list) only to re-create them a few days later when he realized that he needed to continue work on some aspect of the activities. In the end, he opted to leave all of the activities open that he imagined he might possibly need to return to at a later point in time. This observation highlighted a weakness in Giornata's interaction design: the current implementation of the system makes no distinction between *dormant* activities and those that are *completed*, which raises further research questions about how individuals think about the stages in an activity's lifecycle.

Participants also described utilizing a variety of activity switching behaviors, which were often closely linked to the ways that they distributed their applications among their activities. Participant F1 used the first activity created by Giornata as a kind of generic work hub, placing her primary e-mail window (i.e., the window containing a listing of all messages in the inbox) in this activity. When new e-mail messages arrived, she would open these messages in their own windows and move them to the most appropriate activity as reminders to engage their contents more deeply or to send a reply. Participant F2 adopted a strategy of opening multiple copies of his primary e-mail window in different activities so that e-mail could always be close at hand, reducing the need to switch back to a single location repeatedly. In contrast, participant G1 intentionally grouped all of his electronic communication and information foraging tools, including his e-mail application, web

browsing windows, and RSS news aggregator, into a single activity so as to reduce the distraction that these tools could create when he was engaged in a focused work activity.

In general, several features of Giornata—particularly the ability to create and maintain an arbitrary number of activities at different levels of semantic granularity—enabled the flexible appropriation of Giornata by the study participants. The participants were able to take advantage of the features of Giornata in a breadth of ways that fit into their established personal work practices.

Adoption of Activity-Based Desktop Storage

All participants reported using Giornata's activity-based desktop storage. However, the number of files stored within particular activities varied from no items (primarily within communication-oriented activities) to tens of items. Participant F1 said of this per-activity storage that "it feels better than filing," explaining that being able to store files on the desktop caused less anxiety than trying to find the "right" place to put things in the folder hierarchy—an experience she referred to as "soft filing." Participant G2 echoed this sentiment:

> I do really like the fact that I have separate [virtual] desktops and the files go to separate places…I hate navigating through hierarchies, in general…. So, I'd say the file grouping is the biggest win so far (Participant G2).

Participant F2 appreciated the fact that the per-activity storage actually allowed him to keep *more* items close at hand than he would have previously:

> Actually, having different files on the desktop is a big plus…because I had tended to adopt the approach of trying to keep only one column [of files] on my desktop…because [otherwise] I'd never see them…and that meant that I really didn't have much at all there, whereas that changed a little in the sense that I now can have sort of a column per [activity] and it's less annoying because most of the files on any given [virtual] desktop are related to that [virtual] desktop, that activity (Participant F2).

The per-activity desktop storage was perceived by the participants to be so central to Giornata's representation of activities that they often assessed the effectiveness of the system in supporting their activities by commenting about the contents of their virtual desktops. When participant F1 reviewed the virtual desktop contents of several activities during the midpoint interview, she commented there were very few "non-activity" items on any of her virtual desktops, which led her to speculate that the system must have allowed her to create "the right scope of activities."

The participants were quick to identify new information organization strategies that they had developed while using the Giornata system. Participant F1 adopted an approach of moving old project-related folders from her previous desktop structure onto the associated activities' virtual desktops: "I think part of what I've started doing was creating more depth in the structures…. So I essentially use that [the archival folder on the desktop] so that it's accessible from my…activity." Participant F2 described a different approach, using the evolving contents of his desktop as a forcing function for *creating* new activities:

> In the end, interestingly, I found that I created contexts based on how much stuff I had on my desktop…. My work pattern became: I would use the desktop in a given context and if I would notice that I had stuff on my desktop that wasn't related to my context, I would move it to the "slough" one at the front—my unnamed one—and then when that started to get a lot of stuff related to one thing, I would create a new context and put it there (Participant F2).

Participant G2 had a pre-existing practice of archiving all of his information to an organizationally maintained server using CVS[3]. As a result, he developed a different interpretation of the per-activity storage as a sort of "temporary holding area" where he kept a duplicate copy of his work-in-progress folder and any ancillary information that he downloaded from the World Wide Web. Whenever he would reach a milestone in his work, he would copy the contents of his work-in-progress folder back to the CVS-controlled folder and then sync it to the server. Although this process required some degree of management overhead, the participant still considered the practice useful: "The stuff that I'm working with at the moment sits on the desktop so I have easy access to it" (Participant G2).

This tension between adopting Giornata's activity-based organization and continuing to take advantage of pre-existing information management strategies was cited as much more of an issue by other participants. Participant G1 had a long-standing practice of storing his files in a particular folder hierarchy outside his normal OS X home directory. For him, the benefits of the per-activity storage simply didn't outweigh his inertia in continuing to manage his content using his established practices: "I don't store stuff on the desktop generally…and that part of my habit didn't change…. If I put anything on the desktop, it's because it's *really* transitory" (Participant G1). Participant H1 relied heavily on the Finder's ability to sort and filter files, a feature that he missed when he tried to adopt Giornata's desktop-centric approach to resource storage:

> I've been storing things on the desktop, but I don't know what I think of that yet. Sometimes, it's really nice that there are some files that are right there, but others…. So, I'm looking at [project] right now and I have the [file] version 1.0, 1.1, 1.2, 1.3… they're not really in any order whatsoever on the desktop, which kind of makes finding the latest one a little more challenging…. If it was in a traditional folder structure, it's a little bit easier to do the sorting and that sort of thing… (Participant H1).

This participant went on to explain that Giornata's focus on appropriating the desktop as a per-activity store raised additional concerns related to his own personal preferences for organizing information:

> I guess I should also say that I'm one of those people that likes things to be "neat and clean"…but, if I let things go, it's going to reach a very bad state before it gets back to

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[3] Concurrent Versions System, http://www.nongnu.org/cvs/

clean. And I fear…when I look at stuff on the desktop, that's the fear I have…if I don't do something, it's going to get really bad before it gets back to good (Participant H1).

Participants seemed to appreciate having a lightweight mechanism for storing content associated with their activities, and cited the visibility of the desktop as a compelling reason to store their resources in this way. However, despite the benefits of this interaction design, several participants voiced concerns about how this new practice conflicted with existing organizational practices and how it made it somewhat more difficult to apply sorting and filtering over information associated with the activity.

Activity and Information Resource Tagging

When asked about their activity tagging practices, most participants expressed limited enthusiasm for the feature with respect to short-term activity organization. Participant G2's response was representative of most participants' view on using tags:

I think the tagging *might* be useful. I didn't really use tagging that much for search, but that's probably because my projects are so tight…that it wasn't that useful. But I can imagine when I return to a project at some point…I doubt I'll be able to find everything that I wanted from it, so I imagine that the tagging would be useful in that regard (Participant G2).

Participant G1 echoed this sentiment, generalizing from the short-term utility of tagging to the larger idea of using activities to organize his work:

I haven't benefited from the payoff…it seems like the lifecycle for the benefit is a bit longer than the two or three weeks that I've been using it, so…it's six months from now when I'm thinking, "Oh, I wrote this paper on this thing, and I know that there's something connected that I have with that…let me go find it." So, within this short period of time, it's hard to know what the benefit is (Participant G1).

A small but significant number of activities, distributed across multiple participants, remained untagged throughout the entire study. These "untagged" activities were often used as hubs for "metawork" tools [8]; occasionally, they reflected very short-term activities.

Participants were generally hesitant to pass judgment on the value of tagging their activities, generally anticipating that the real value of this feature might emerge over time.

Use of Collaboration Features

The participants reported much less frequent use of the Giornata system's collaboration features than of those features geared towards supporting individual multitasking and information organization. Participants provided two main explanations for why, in most cases, they opted not to assign contacts to their activities: first, several participants did not store their contact lists in the OS X Address Book application, which provided the basis for the Contact Palette's directory of possible colleagues; second, the Contact Palette interface lacked tools for efficiently searching or filtering long lists of contacts.

When participants did create activity–contact associations, one of the primary reasons participants cited for doing so was to take advantage of the e-mail notification capability that this enabled. One of the unanticipated side effects of these notifications was that they served to heighten some participants' awareness of communicative practices within small groups. Participant G2 commented that his use of the feature revealed the importance of different colleagues' roles in the context of an activity:

I did put [*colleague names*] in my Contact Palette sometimes, but because…all [these colleagues] are above me in the hierarchy that means that I e-mail them and they don't e-mail me, in general. And, so, the Contact Palette is not so useful. It *was* more useful for the [smaller project], because I had [*colleague*] and [*colleague*] in the Contact Palette…and it did have some utility there (Participant G2).

Other participants felt overly constrained by the way that colleagues had to be associated with each activity in Giornata. Participant F2 expressed a desire to be able to construct groups of colleagues that could be shared from activity to activity and to be able to declare a subset of close colleagues as relevant to all activities. Participant H1 had a particularly succinct way of describing this phenomenon in the context of his work: "I don't have a 1-to-1 mapping between people and activity." He suggested that providing the capability to link activities with larger social structures, such as e-mail distribution lists, might better represent the more group-oriented ownership of projects that he frequently encountered in his workplace.

There was no reported use of the Contact Palette to informally share files or to quickly retrieve relevant information about a colleague. These features may require additional exploration once barriers to the overall adoption of Giornata's collaboration tools have been addressed.

However, even when participants did not use the system's collaboration features directly, they commonly reported that the system still provided implicit benefits for collaboration: "Unfortunately, I didn't get to take advantage of [the Contact Palette], but [Giornata] made me better organized and that helped with collaboration" (Participant F1). Participant G2 took a pragmatic perspective, noting that before the study the best collaboration tool available to him was e-mail and that "Giornata can only improve things."

Collaboration was clearly one of the most challenging aspects of knowledge work for the Giornata system to support. Participants were able to use the collaboration features of the Giornata system with varying degrees of success, based largely on their existing knowledge work practices and the inertia involved in their use of personal information management tools. Even so, the features were sufficient in some cases to elicit valuable feedback, particularly with regard to organizational communication practices within and across activities and an unexpected phenomenon that can be broadly characterized as "collaboration awareness."

DISCUSSION

Because Giornata is one of few systems that provides individuals with the ability to divide all of their work into discrete, holistically defined activity clusters and one of the first to be studied at length in a real-world setting, our findings illustrate how individuals might adopt and appropriate systems in the broader class of activity-based technologies. The findings can also provide a useful lens for reflecting back upon previous characterizations of knowledge work and the theories that have been generated to describe the structure and content of these professionals' work practices.

The empirical studies carried out by Kidd [12] and Barreau and Nardi [3] resulted in the identification of several characteristics of knowledge work, many of which influenced aspects of the Giornata system's design. By examining how the participants in the deployment and study responded to these aspects of the completed system, the claims can be assessed from a new perspective.

A Low Dependence on Filed Information

"Knowledge workers, in general, have a low dependence on filed information" [12].

"Users keep little archived information in their systems" [3].

Participants in the Giornata deployment discussed their use of the system almost exclusively in terms of the artifacts that the system allowed them to keep "at hand." Those participants who reported having formal processes for moving content from activities into long-term archives (e.g., participant G2's use of CVS) talked about taking these steps primarily at activity milestones and primarily for the purpose of having a back-up copy of the information stored on a file server. These findings confirm the primacy—at least on a day-to-day basis—of information resources immediately relevant to ongoing activities over artifacts that have already been classified and archived.

Furthermore, the study participants "closed" activities very rarely over the course of the deployment. Instead, most participants kept their activities open, either leaving their content in whatever state that it had been in while working on it (implying that the "working state" of the per-activity storage was "good enough" for the long term) or simply re-conceptualizing the objective of the computer's activity representation to reflect a transition to a new, related task.

A potentially interesting follow-up study would be to examine how files are managed when these kinds of systems are used over the very long term: would individuals be more likely to archive documents associated with activities within the activities themselves or to intentionally move artifacts into other, more structured file hierarchies when activities are brought to a close?

Use of Spatial Layout[4] as a "Holding Pattern"

"The spatial layout of a knowledge worker's materials is important as a 'holding pattern' for short-term organizational purposes and before the materials have been classified and can be filed" [12].

"Users overwhelmingly preferred location-based search.... Users consciously organize their files for easy retrieval" [3].

Our participants strongly validated these claims about knowledge workers; they almost unanimously cited the per-activity storage as being the most compelling feature of the Giornata system. Participants talked about how storing items on each activity's virtual desktop felt "better than filing" (Participant F1), that the system's design resonated well with existing practices of storing "temporary" or "working" versions of files on the desktop, and that having a place to collect all of the items related to an activity significantly strengthened the relationship between real-world activities and virtual workspaces. The relatively common use of untagged activities as a "holding pattern" for materials that did not yet have a formalized purpose or structure (e.g., Participant F2's use of an un-tagged activity as a "slough" space) also supported this assertion.

While empirical characterizations of knowledge work have identified the importance of the spatial organization of short-term and transient artifacts in making sense of ongoing activities, in general, systems designed to support knowledge work have failed to emphasize these needs in their design. Participants F1 and F2 both noted that managing the volume, structure, and location of artifacts on their activities' virtual desktops had become a key aspect of their organizational practices during the study. Participant H1's comments about the importance of the *sorting* and *filtering* capabilities of traditional file browser windows for finding and tracking multiple versions of files suggest that spatial layout, itself, may not be sufficient for managing the increasing number of digital artifacts that knowledge workers bring to bear on some of their activities.

Use of Spatial Layout as a Primitive Language

"The spatial layout of a knowledge worker's materials is important as a primitive language, since the physical (and, presumably, digital) artifacts stand in as a model of real-world phenomena" [12].

A significant percentage of the activities defined using Giornata were tagged with project names, organizations, or events—the same identifiers used to describe ongoing conceptual units of work prior to the deployment of the Giornata system. One of the participants who had previously used (and subsequently rejected) other virtual desktop software speculated that he had been more successful using Giornata because it provided a better

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[4] Kidd's use of the term "spatial layout" refers to the organization of a knowledge worker's entire physical workspace [12]. In this context, we are broadly interpreting the term "spatial layout" to mean the overall organization of a knowledge worker's digital artifacts, not merely the placement of file icons on the computer desktop.

mapping between real-world activities and virtual desktops than did other systems. These observations support the claim that digital artifacts stand in as a model for real-world conceptualizations of activity and that the closer this mapping can be, the more likely the system might succeed.

Use of Spatial Layout as a Reminder

"The spatial layout of a knowledge worker's materials is important as a contextual cue for resuming a suspended activity, the location of artifacts helps to answer the question, 'where was I?'" [12].

"The location of information on the desktop…serves a critical reminding function. Users…were observed placing files in locations where they were likely to notice them" [3].

The study confirmed many long-standing assertions that representations of activity are a powerful tool for reflecting over the landscape of activities currently under way and reminding knowledge workers about work that still needs to be done. Participants in the study talked very specifically about using Giornata's open activity list in lieu of to-do lists, and several participants made suggestions about how the system's visual representation of ongoing activities could be strengthened to improve its usefulness as an "at-a-glance" tool for assessing the state of all open activities.

Use of Spatial Layout as Demonstrable Output

"The spatial layout of a knowledge worker's materials is important as demonstrable output, since piles in some ways quantify the work that has been accomplished" [12].

During the semi-structured interviews, participants frequently referred back to their activity lists as evidence of the progress they had made in organizing their ongoing activities and accomplishing their activities' objectives. The language used by many of the participants when talking about their ongoing activities suggested that they evaluated their success in completing an activity by whether they felt that they could "check it off," that, in essence, the fewer activities they had open in Giornata, the less outstanding work there was left to do.

Activity Theory and Activity-Based Computing

The design of Giornata was also heavily influenced by cognitive representations of activity, especially Activity Theory [7, 11, 14, 25]. This theory suggests that activity-based systems should provide a series of discrete activities with each incorporating the diversity of tools used to accomplish that activity as well as representations of the social context within which the activity takes place.

While the computational representations of activity inspired by this model were praised by the participants for unifying many of the relevant aspects of an activity in a single interface, several tensions were also uncovered. Participants appreciated the fact that Giornata allowed them to separate their work into distinct activities, enabling them to keep more of the "relevant" resources for their work at hand at any given time. However, use of the system revealed an unexpected level of interconnectedness among the activities that these participants defined. Not only were information artifacts (e.g., documents and e-mails) shared across multiple activities, but several participants pointed out a frequent need to access instances of running applications across multiple contexts, as well. This apparent contradiction begs a number of questions: Do the "soft boundaries" that participants reported around their activities suggest that the ad hoc definition of activity structures is inherently error-prone? Can activities actually be represented as distinct clusters of tools and artifacts in practice? Does the interdependence and complexity of an individual's real-world activities necessitate that computational representations encode the relationships among activities in addition to the structure within them?

Giornata also provided simplified representations of the social contexts surrounding individual activities by persistently displaying a list of the colleagues associated with each activity and a series of related awareness cues. However, several participants provided feedback that maintaining these representations of social groups within activities was difficult and time-consuming, commenting that the individuals and groups that they associated with one activity were likely to be relevant collaborators within other activity contexts at the same time. One of the study participants (H1) drew particular attention to this problem, suggesting that instead of social contexts belonging to activities, it would be more useful in his work environment to define activities from within a social context; that is, given an existing team in the workplace, a better approach might allow activities to be created based on the existing composition and shared resources of that team. At a minimum, he—and other participants—pointed out that it should be possible to more readily share representations of pre-existing social structures across multiple activities.

In general, the study revealed that although activity theory might work well as an analytic tool for *understanding* activity, applying these models as a framework for *organizing* work in the real world requires significant effort to support "tool" re-use across multiple activities, to represent the sometimes-complex interrelationships among activities, and to provide interfaces that reflect appropriate association between activities and social groups.

CONCLUSION

In this paper, we have presented in-depth results from an *in situ*, longitudinal deployment of a fully functional activity based computing system to a small cohort of knowledge workers. In our study, we focused on deriving a better understanding of the ways in which Giornata influenced knowledge workers' existing work practices in the context of their own tools and information resources. In general, the successful adoption of the system can be attributed to the variety of ways that Giornata was able to be appropriated by knowledge workers with diverse sets of work practices.

Our results represent contributions at two levels. First, our findings contribute a better understanding of the influence

of the specific features of Giornata on knowledge work practice, including:

- The per-activity resource storage was cited as one of the "biggest wins" in using the system; of all of Giornata's features, this one was perhaps the most well received and actively adopted.

- In general, the participants believed that activity tagging provided relatively little value in the short term and that the real value in tagging activities and their associated contents might not be realized until months later.

- The organizational affordances of the per-activity storage provided participants with a degree of "collaboration awareness," even with limited use of the system's collaboration features.

Additionally, our results contribute to a larger, ongoing discussion within the HCI community about the role of activity in knowledge work, particularly with respect to the significance of the spatial layout of knowledge work artifacts and the feasibility of using discrete activity representations in computational systems. We have provided initial evidence of the ways that existing observations of work practices do and do not bear out when knowledge workers shift their work into an activity-based work environment. Our study also suggests important topics for future research, including the need to better understand the nuances of activity lifecycles in knowledge work.

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