

---

# UNDERSTANDING OFFICE ECOLOGIES

## DISTINGUISHING BETWEEN DIFFERENT OFFICE DWELLER TYPES

JUSTIN KODAMA AND SHAIENDRA RAO

INTERACTIVE COGNITION LABORATORY  
DEPARTMENT OF COGNITIVE SCIENCE  
UNIVERSITY OF CALIFORNIA, SAN DIEGO

WEB: [ADRENALINE.UCSD.EDU](http://ADRENALINE.UCSD.EDU)

EMAIL: [JUSTIN@JUSTINKODAMA.COM](mailto:JUSTIN@JUSTINKODAMA.COM), [SHAILO@SHAIENDRARAO.COM](mailto:SHAILO@SHAIENDRARAO.COM)

---

## 1 STATEMENT OF PROBLEM

What would it take to enable people to:

- Interact with their offices not only physically, but digitally so that they can visualize the contents of their physical desks and shelves enriched with metadata about their work histories?
- Project their necessary work materials into new physical venues while maintaining the essential cognitive structuring, ordering, and spatial location that was present in their original offices to preserve a familiar feel?
- Resume their workflow with minimal disruption at any time or any place?
- Simplify and sort the ordering of their workspace on demand?

A hybrid office, an office that combines the richness of the physical environment with the efficiency and automation of the digital world would afford people with the capability to conduct the aforementioned tasks.

To create such hybrid offices that would allow people to seamlessly take advantage of what both the physical and digital worlds have to offer, we propose to model the underlying cognitive state of a physical office. With this modeling we can then project the salient aspects of this cognitive state onto walls as well as desks onto tablet PC's and handhelds, allowing office dwellers to utilize their office resources in new and more powerful ways. The powerful visualizations provided by these projections help create a 3D Portable Office (3D-PO), a digital model of the key resources in a physical workspace. To make it possible to project this digital modeling of the essential office content we will also be designing:

1. methods to capture the office context
2. ways to visualize the state of an office so that users can sort and group content in a manner that accounts for their history of interactions with the office resources
3. projection rules for displaying information on various surfaces

The basic premise behind 3D-PO is that it is possible to provide users with a collection of digital supports that enable them to both recreate and manipulate the essential physical resources they need at any given time and place with enough fidelity that they can harness their habitual work practices. Digital supports are portable viewable versions of common office surfaces (e.g. desks, shelves, walls), office containers (e.g. filing cabinets, trash cans, folders, etc), coordinating structures (e.g. post-it notes, calendars, filing systems, rolodexes, and input/output trays), and

content (e.g. papers, books, files, folders, and piles). While the physical versions of these office elements that we have become accustomed to working with do not explicitly indicate where they have been, who has used them, what they have been used for, and when they were used, the digital versions we are proposing will offer users these abilities. These digital versions will store the history of interaction between user and office artifact which can then be displayed explicitly upon user request. For instance suppose Ralph wanted to quickly find all of the comments and feedback a coworker Malcolm made on a research paper he was working on. In today's office, this would involve Ralph physically rummaging through stacks on paper his desk flipping through hundreds of filed documents in his filing drawer, and sifting through an overflowing trash basket all with the looming possibility that he will never find Malcolm's comments because they were all discarded when the janitor emptied his trash basket several days ago. In stark contrast to the inefficiency and ineffectiveness of today's office that plague Ralph, the 3D-PO office we are proposing would be able to display the activity history (i.e. the physical trajectory of the documents and materials related to the research paper as well as who made what annotations when) of the document he is interested in by storing important metadata about every physical item in an office space. In a digitally supported office, cumbersome tasks such as the one interfering with Ralph's progression on his research paper are reduced to effortless reading and manipulating of digital displays.

To ensure that 3D-PO users can resume their work at different venues and times with an insignificant adjustment cost, we propose to preserve the essential "deep structure" of a person's work environment. Our method of preserving the fundamental deep structure of people's office rests on the postulation that this can be achieved by narrowing focus to the recreation of only the key physical resources that are of the utmost cognitive importance to the worker and their

activity. This means that in order to preserve the necessary deep structure of a person's activity space, which will allow them to efficiently return to their tasks from the referent office location, we need not store and recreate every single element, but rather we must maintain user's spatial layout preferences (e.g. few visible items), organizational strategies (e.g. strict filing system), functional spaces (e.g. input/output trays that dictate the order tasks are approached), and coordinating representations (e.g. calendars). Retaining users "entry points" or attention getting piles and cues (Kirsh 2001) must also be sustained if we are to preserve the deep structure of an office. If our 3D-PO system is able to store the rudimental metadata or attributes about the essential office elements and user preferences as a means to capture the deep structure of a workspace with enough cognitive fidelity that workers can easily adapt to their new workspaces, then our projections will release office workers from their dependency on a particular office location.

In order to provide digital support for the diverse ways users interact with their physical desk and other resources in their offices, we must conduct ethnographic studies of real world office workers in their offices. Doing so will enable us to both develop an ontology of the rich elements populating current offices as well as formulate an ontology of the agent's actions that can take place in this activity space. Because 3D-PO relies on the ability to continuously model the state of an office, we need to categorize all of the possible elements of an office and make note of the opportunities they afford to a user. This translates to generating an office ontology and activity ontology by indexing the containers (e.g. filing cabinets, binders, folders, etc.) that can contain paper documents which can be sorted by title, relevance, or recency, the surfaces (e.g. desktops, shelves, cabinet tops, etc.) where office elements can be placed, and the content (e.g. articles, telephone numbers, memos, etc.) which can be linked to other information or

people. Based on this production of an ontology the basic elements in an office and all of their possible states, we can define higher order attributes of an office such as entry points. In conjunction with the stored metadata about every single office element our office and activity ontologies will help inform the design of a 3D-PO that allows office dwellers to effortlessly resume their familiar work practices at different venues.

Conducting our ethnographic studies of live office dwellers in their office to spawn these ontologies will illuminate the fact that different people have different habits. We will see the vast array of elements inhabiting these office spaces, the various ways in which people use these elements, and the different routines people perform with these artifacts. Seeing our users in this new light with respect to their organization of these elements and their routine patterns of usage will serve as the empirical base for testing the adequacy of our ontologies. Bereft of the digital supports that 3D-PO provides, these ethnographic studies will reveal how office workers currently mark up, classify, sort, and search for objects during the course of their work activities.

Once we have formulated a clearer understanding of what activities occur in office spaces through our ontologies and ethnographic studies of actual office behavior, we can design the visualizations that our hybrid office dwellers can employ to digitally mark up, classify, sort, and search through their office elements. For instance, several months after completing his research proposal, Ralph wishes to collect all of the sources he used to write the background portion of his research paper complete with all of the notes and comments he made while reading and reflecting, so that he can compose a related document. In today's office, Ralph would have to spend hours practically turning his office upside down by foraging through his backpack, his filing drawers, the piles and stacks of paper on his desk, and his trash basket to find the correct papers that he annotated to help him construct his research paper. Resuming his thought process

even at this singular office location is an incredibly arduous task. Picking up his cerebration at a different location only compounds Ralph's dilemma. With the information visualizations provided by 3D-PO Ralph could utilize several tablet PC's that display all of the sources he is looking for with the annotations that he made projected onto the digital versions of these documents, instantaneously upon demand. He could also take advantage of visualizations of his activity history with these documents showing when he made certain notes as a means to recreate his once lost train of thought. Creating visualizations such as the previously illustrated one that are informed by the understanding of what actually takes place in an office environment which we aim to gather in the first phase of our project will ensure that 3D-PO provides users with an information rich enhanced activity space.

Finally we will test the usefulness of our hybrid office that endows today's office with powerful information visualizations in two ways. The first method would be conducting controlled experiments containing user experiences on a set of common tasks where they have access to the visualizations that 3D-PO affords to their productivity in a standard office without these digital supports. Our second method of measuring the adequacy of our digital designs centers around analyzing our ethnographic research for a baseline account of everyday cognitive activity in today's office. The combination of these two methods that test the adequacy of our digital designs will inform us of the necessary improvements for future iterations of 3D-PO.

## 2 BACKGROUND

### 2.1 UNDERSTANDING TODAY'S OFFICE

Before we can begin to produce a hybrid 3D-PO that features powerful visualizations which allow people to work and think more efficiently, we must develop a clearer understanding of what takes place in today's office context. Doing so will enable us to decide what activities require what types of digital supports.

#### 2.1.1 OFFICE ORGANIZATION

In analyzing office ecologies (Kirsh 2001) we must first consider how people structure their office spaces. Office dwellers live in a world filled with surfaces such as desks, shelves, cabinets, and walls; they rely on diverse coordinating structures such as calendars, filing systems, computer directories, rolodexes, personal information managers (PIM's), cell phones, phone directories, desktop organizers, forms, routing slips, and input-output trays; they move paper, files, sticky notes, letters, folders, and cover sheets on surfaces, between offices, to other people, and between input-output trays; they copy content from physical paper to digital files, they convert digital files to paper copies, they photocopy, scan, trash, and more all as a matter of course in their everyday activity. With such a plethora of information being supplied and demanded as well as the need to multi-task and handle a variety of workplace interruptions it is no wonder office workers suffer from cognitive overload (Kirsh 2000). Previous studies on the units of desk organization as well as how people employ their activity spaces on a high level ordering as extensions of their cognitive processes shed light on what our office ontologies must consider.

## UNITS OF ORGANIZATION

Because of finite office spaces, people are forced to manage the spatial layout of their office resources which in turn becomes an integral aspect of people's thinking, planning, and behavioral processes (Kirsh 1995). Malone's study on how professional and clerical office workers organize their desks revealed two fundamental units of desk organization, files and piles. Malone classified files as explicitly titled and systematically arranged elements, while also observing that people make use of piles, first-in last-out (FILO) stacks without any particular order or explicit titling. Illuminating a key cause for these loosely structured piles, Malone provided evidence that people have cognitive difficulty classifying information. People form piles to avoid characterizing office elements and because they have trouble "deciding what the categories are and what category something is in" (Malone 1983). Mander et al conducted user interviews generating the similar finding that people used piles, loosely categorized documents, instead of hierarchical folders to avoid detailed categorization tasks.

Both Malone and Mander et al have raised an important distinction between two units of organization found in offices. However, neither study provides enough empirical support to make a clear finalized distinction between these organizational units. Based on interviews and questionnaires these studies are only a start as they lack the ethnographic methodology that we aim to provide to support this pile and file classification scheme. Upon determining if these units are helpful for understanding office ontologies, we will use this knowledge to inform the design of the visualizations 3D-PO boasts to augment the user's spatial layout and classification preferences.

## HIGHER LEVEL ORGANIZATION

Understanding the way people organize their offices from a higher level beyond the file and pile units elucidates that office spaces have a structure or context that supports the user's tasks (Kirsh 2001). To attain a truly portable 3D office which enables people to resume their workflow with minimal disruption at any time or place it is imperative that we understand and preserve this deep structure. In his theoretical paper *The Context of Work*, Kirsh posed a series of questions that must be addressed if 3D-PO is going to capture and represent the deep structure of a work context:

[H]ow is information about the context of work stored on physical desks, office walls, whiteboards and shelves? What coordinating mechanisms do individuals and small groups rely on to synchronize activity, distribute tasks and activities and manage at hand resources? What critical elements of a work situation cue memory, making it likely that office users will recall why they left papers out, why folders are open, why there are certain marks on the whiteboards, and so on?

Comprehending the higher level meaning of an office environment rests upon conducting empirical studies to test and challenge the theories and observations that have already been set forth.

The theoretical concept of entry points which Kirsh explored are useful for looking beyond the superficial characteristics of an activity space (Kirsh 2001). Entry points are structures or cues that act as invitations to partake in some activity. During the course of the work day, office workers position entry points so that they may easily return to work tasks. For instance, a person might place the telephone bill near their keyboard so they will both remember to pay the fee through the company's website and be able to quickly find the statement when they are ready to file it away. The phenomenon that people organize their desk space to cue them

to do some task was also observed by Malone who noted that two important functions of desk organization are helping people find the things they are looking for as well as reminding them to do a particular task (Malone 1983). Through three unstructured interviews with desk users, Tyson (1992) also noted that people annotate and organize their artifacts in a manner that will remind them of things to do. By providing an extensive ethnographic study to augment Kirsh's concept of entry points, Malone's observations of the finding and reminding functions of desk organization, and Tyson's recognition of office reminders, we will be able to further an understanding of the higher-level attributes of the elements in an office. Gathering data about how people functionally structure the spatial layout of their office spaces to aid retrieval and recall, informs the design of digital aids that recognize and capture these higher level meanings.

### 2.1.2 OFFICE DWELLER TYPES

Understanding the units of organization and the higher level structuring of office workspaces is just the first step to understanding the interaction between office dweller and office environment. We have already revealed that office environments can be seemingly chaotic places as office dwellers can partake in a wide array of activities- filing, faxing, writing, typing, trashing, etc. People need coping strategies to make sense of this seemingly hectic office world. It is important to note that people can differ greatly in their coping strategies. Accounting for the range of possible user types and preferences is crucial if 3D-PO is going to project visualizations that enhance the essential office elements in a manner that feels natural to the user.

## NEAT AND SCRUFFY

By investigating how office dwellers' tasks are both reflected and shaped by their office space, we can begin to categorize our users into different user types. Both Kirsh and Malone have raised a distinction between office dweller types who differ both superficially with respect to the spatial layout of their offices and in the deep structure of their office environment. Both Kirsh (2001) and Malone (1983) classify Neats as people who maintain tidy, strictly organized office spaces (see Image 1). In contrast to Neats, Scruffy or Messy users, as Kirsh and Malone explain, keep slovenly offices with less rigid structure, which in turn creates a highly data-driven environment with large amounts of information access and visibility (see Image 2).



Image 1: A Neat Workspace

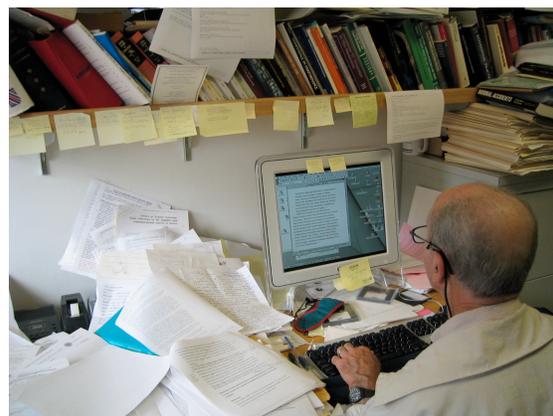


Image 2: A Messy/ Scruffy Workspace

Kirsh makes the distinction between Neat and Scruffy office personalities with respect to the different inclinations and acceptance users have for the number and kind of entry points in their office workspaces. As Kirsh contends, each organizational strategy has its own advantages and costs. While Neats benefit from systematically structured environments with entry points that

help them plan and schedule their day, Scruffies enjoy highly data driven workspaces that contain sizeable information with low classification requirements. However, both personalities have their shortcomings as Scruffies suffer from longer search times because of the dense amount of information packed into their offices as well as the indistinctness of their entry points and Neats have less opportunism, the probability of realizing the ways that tasks not currently within the user's focus can be advanced, and also a cost in time and cognitive effort in maintaining rigid organizational schemes. Malone differentiated offices as Neat Offices and Messy Offices with respect to the number of files and the degree of relatedness of the elements in piles. Idealized Messy office organizations were saturated with vaguely grouped piles contrasting the abundance of ordered files and semantically tight piles.

The Neat and Scruffy dichotomy is useful for developing a 3D-PO system that caters to the different organizational strategies of office dwellers. For instance, since Neats prefer less visible items on their desk spaces, the information visualizations enriching their office workspaces must consider this penchant for focused highly organized presentations. The distinction Kirsh and Malone have raised is useful, but lacks the empirical support, as this research was based on informal pilot studies with limited users to distinguish whether there are distinct types of users or a continuum of users plotted on a line with idealized Neats at one end and idealized Scruffy at the other end. Moreover, more work is needed to identify the different dimensions of activity that together support the Neat and Scruffy distinction. With our user studies we will be able to further an understanding of the office ontology by determining how to maintain the natural feel of office dweller's personalized workspaces at different venues and times.

## 2.1.2 TOWARDS UNDERSTANDING AN OFFICE ECOLOGY

To an outsider, the occurrences in an office may only appear to be the interaction between the office dweller, their desk and computer, but this is not the case. What occurs in an office is more than just a desk. The interactions in an office involve a wide variety of various influences such as dealing with visitors and interruptions, accessing filing cabinets, moving piles of paper around on one's desks, and also understanding how each person prefers to work. In order to formulate a descriptive account of an office ecology, we need to consider the various factors, parameters, and context that influence how the office dweller and his or her office interact.

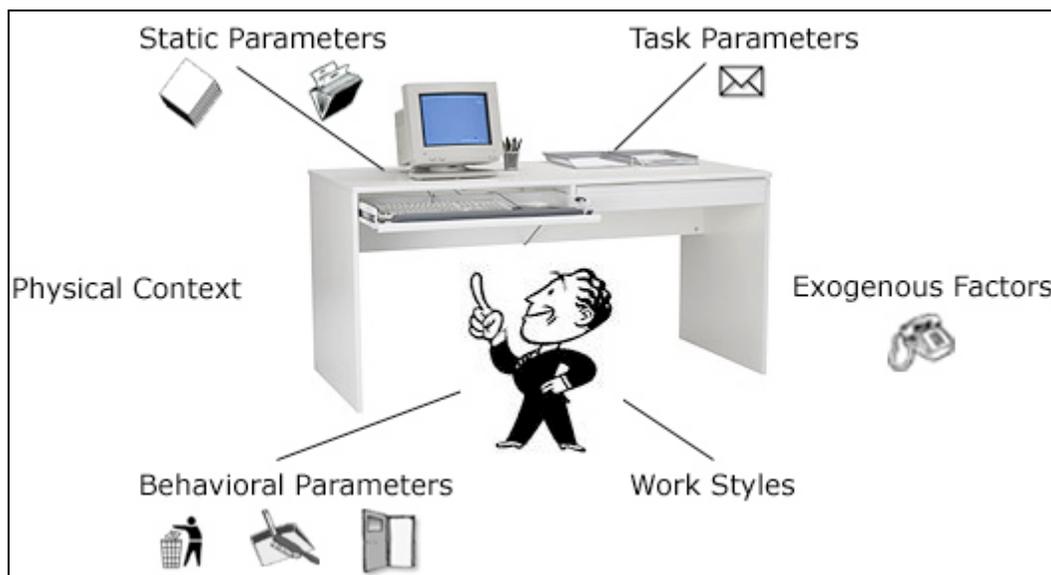


Image 3: An office is More than a Desk- it is an Ecology. There are many factors that go into an office.

First, the physical context of an office is made up of the number of surfaces and their size as well as the number of filing cabinets. This physical structure of an office can cause limitations on how one works. For instance, if the office worker needs two filing cabinets to accomplish her tasks, but is only supplied with one in her office and one in a room two doors down, this greatly affects how she works. She may create piles of papers on her desk that are to be filed away in the

filing cabinet outside of her office, whereas if the second filing cabinet was in her office, those papers would never reside on the desk, she would file them away immediately. Office dwellers must deal with these limiting factors and adjust their work styles and preferences accordingly.

Static parameters are the observables of an office, or more simply, it is the stuff that you can look at. For example, how many piles are there on a desk and how much space does each pile occupy? If there are multiple piles on a desk, how much pile spanning is there, is each pile clearly defined or do they overlap? Other important observables include, the number of impromptu note-taking devices, such as sticky notes and notepads. It is also important to look at the number of open folders and also the number of open projects. All of these combine as the static parameters of an office, the amount of things a visitor could count that appear on the surfaces in an office.

The third aspect necessary to defining an office ecology are the task parameters, which describe the nature of an office dweller's work. Visitors and phone calls interrupt the tasks of the office workers, but does the office dweller let these interruptions change their current task or do they continue working on their original task and deal with the interruption later? Also, it is important to know what types of things structure their workday such as calendars or day planners. These give insight into how the office dweller knows what tasks to work on and also how each worker handles their tasks. Another aspect of task parameters involves how they handle their mail. Some people may sort their mail at their mailboxes, throwing away junk mail immediately while others will grab their mail and without delay return to their office to sort through it. These task parameters will help determine how office dwellers approach their tasks for the day.

Outside influences such as visitors or phone calls are referred to as exogenous factors. These may cause short interruptions or cause the worker to completely switch tasks. How the worker handles these interruptions is an important factor in understanding the office ecology with which they reside. Do these interruptions immediately change their current task or do they put the tasks brought about from the interruptions onto a queue so that they can be dealt with later? These unexpected influences to their job immediately affect them and it is necessary to find out how each type of office dweller, from Neat to Scruffy, handles the various types of interruptions.

After studying the exogenous factors and parameters that influence how a person works, it is necessary to understand a person's behavioral strategies. These are activities employed by the office dweller that allow them to accomplish their tasks for the day. One of these activities includes the frequency of trashing, how often or how regular does the office dweller remove excess materials from their surfaces? Another important behavioral strategy refers to when or how often they clean up their desk. Does the office dweller clean up before lunch, at the end of the day, or after completing a task? A third important strategy deals with understanding how they stabilize their work before dealing with an interruption. So, when an interruption occurs, does the office dweller put their current task in a state in which they can easily return to it after dealing with the interruption, or do they immediately leave their current task? All of these behavioral strategies will potentially shed light on what kinds of errors they may make as well as how they accomplish their tasks for the day.

Working closely in conjunction with these behavioral strategies are their work styles, in other words, how they prefer to accomplish their tasks. For example, Hojicha might like to have 3 tasks open before closing off any one of them while Chandrasekhar likes to open 1 task and

close it before starting another. Another aspect of one's work styles relates to how they prefer to tackle multiple tasks. Are the short jobs done immediately and then the longer tasks, or are the tasks accomplished in the order with which they were received? These work styles are important in understanding the ways in which different types of office dwellers prefer to complete their tasks.

All of these parameters show that the person works in conjunction with the varying factors of an office, where each influences the other. For instance, the number of tasks open affects the other parameters previously mentioned. If multiple tasks are open, most likely the static parameters will increase as many more piles and folders occupy one's surfaces. Also, if the worker prefers to handle the short tasks first, exogenous factors will greatly shift their attention towards other tasks. All of these factors work together to show that what occurs in an office is definitely more than a desk, it is an office ecology.

## 2.2 CAPTURING OFFICE ONTOLOGIES

The ethnographic study of how users manage their desks creates the foundation for transferring the physical into the digital. This transformation of physical objects in the office environment into digitized versions employs the principles behind ubiquitous computing and context aware computing.

### 2.2.1 UBIQUITOUS COMPUTING

As introduced by Mark Weiser, ubiquitous computing attempts to “make computers an integral, invisible part of the way people live their lives” (Weiser 1991). The office environment therefore is an ideal place to implement ubiquitous computing in order to break from the constraints of a desktop computer and place computing into everyday objects such as paper, trash, files, piles, and folders. All of these common office artifacts are natural to workers such that the complexity of them disappears to the point where workers easily and effectively manipulate the objects. People file documents in folders, stack papers on top of each other, and jot down memos on stick-em’s, all part of their everyday office activities without thinking twice. The performance of these activities while manipulating the artifacts to accomplish these tasks are invisible to the worker, and this becomes the aim of how we wish to digitally support their tasks. As Weiser also stated, “the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it” (Weiser 1991). 3D-PO will employ technologies that disappear cognitively in order to enhance the everyday experience of office worker.

### 2.2.2 CONTEXT-AWARE COMPUTING

To best support the needs of accessing and retrieving relevant information, 3D-PO will employ the principles of context-aware computing. Context, in terms of computing, can be described as the physical location of an artifact as well as the social aspects or state it is located (Moran and Dourish 2001, Dey, Abowd, Salber 2001). Thus, the context for 3D-PO will be the ways in which office workers employ their containers, surfaces, and content in order to best accomplish their tasks, where the physical situation refers to *where* the work is being performed such as the

desk or filing cabinets, while the social situation refers to *what* work is being performed such as writing a memo or retrieving documents from folders. Using this information, we can then refer to Anind K. Dey's definition of context-aware computing, as a system that "uses context to provide relevant information and/or services to the user, where relevancy depends on the user's task" (Dey 2001). 3D-PO will observe the context of the office environment, as previously defined, and provide the necessary information to the worker in order to best support their task at hand. For instance, if Ralph is working on a research paper, 3D-PO will know what Ralph is working on by the documents or books he has opened, and then 3D-PO will make readily available the files and documents relevant to the completion of this task. The principles context-aware computing will allow the system to be designed in such a way that it will know what task being worked on, and then can combine this knowledge with the relevant ubiquitous computing artifacts.

### 2.2.3 CAPTURING CONTAINERS, SURFACES, AND CONTENT

In the office ontology that we have created, there are three main branches of the overall office, containers, surfaces, and content. Content is what allows people or information to be linked such as articles, telephone numbers, or memos. Surfaces are those areas where office elements can be placed, such as desktops, shelves, or cabinet tops. Containers allow office workers to store and retrieve documents ranging from large sizes such as filing cabinets, to more portable sizes such as binders or folders. In order for 3D-PO to effectively implement the ubiquitous and context-aware computing principles, the system must be able to capture these three categories of the office ontology.

Recording and digitizing office elements such as papers, books, post-it notes, and articles will be essential for 3D-PO to begin to function as a ubiquitous computing environment. The notepad envisioned by Weiser is a computerized form of scrap pieces of paper in which people can write notes or draw diagrams (Weiser 1993). Weiser also mentions the creation of a digital post-it, allowing people the ability to jot down phone numbers, notes, or contact information with the same ease of use as a regular pen and post-it would permit (Weiser 1993). Abowd and Mynatt illuminate how capturing user input will be digitized in the form of a computer-based pen and paper (Abowd and Mynatt 2000). Currently, Anoto has designed paper that captures exactly what is written and printed on it, simply put, "The paper is the screen" (Silberman, 2001). 3D-PO will use the combination of the Anoto paper with the digital pens to completely change the way that office workers keep track of their documents.

## 2.3 ENHANCING OFFICE WORKSPACES

In order for the capturing of documents to be most effective, there needs to be a way for the user to sort through and find the digitized versions of physical artifacts via their computer, wall projection, or another surface projection.

### 2.3.1 METADATA TAGGING

First, visualization of the physical entities of the office as digital representations requires each artifact to have its own identity allowing 3D-PO to differentiate between them as well as provide the workers with the relevant documents for the task at hand. Thus, the need for metadata to tag documents with relevant attributes arises. A real world example is a library because it exploits the use of metadata to allow people to search for books by author, title, publication date,

publisher, and more. Each of the books is stored in the library database with data about each book's author, title, publication date, and publisher. As Vaduva and Dittrich implemented in their paper on data warehousing, metadata can be “captured, generated, and managed” to be used for defining an object's structure and characteristics. (Vaduva and Dittrich 2001). With 3D-PO, each document will be captured, generated, and managed using a metadata language such as eXtensible Markup Language (XML) along a set of static categories such as date created, author, or title, as well as along a set of dynamic categories such as who last touched it, when it was last accessed, or where it is located. The use of metadata will be useful in the visualization of the files as we will be able to sort and categorize along any number of categories.

Once the documents have been tagged with metadata, the user can sort or retrieve them along any number of categories. For example, the problem Ralph encountered in writing a related document to his research paper was that he would have to turn his office upside down to find every relevant document because many documents were filed in separate locations. Had he used 3D-PO, all his documents would be digitized along with numerous metadata attributes (see Image 4).

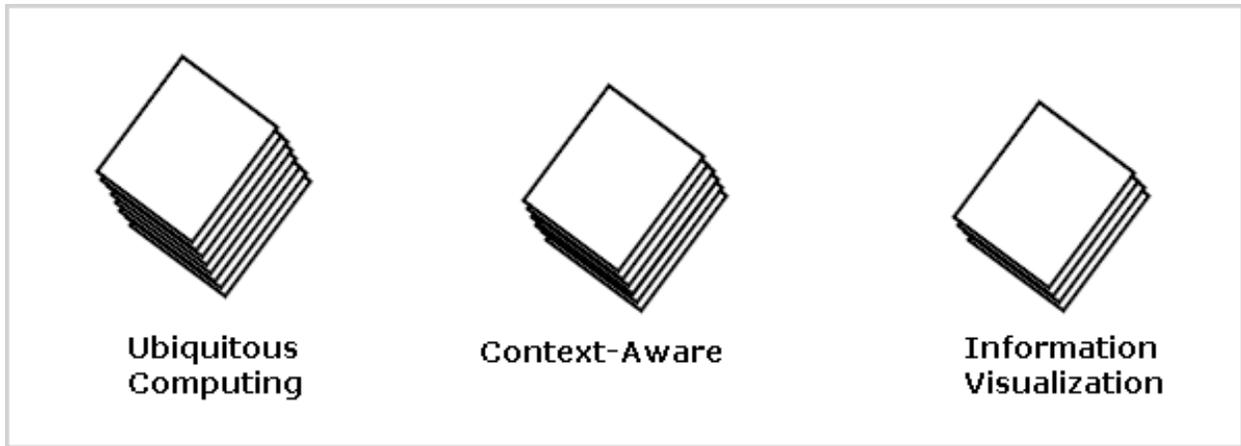


Image 4: Grouping documents using Metadata.

One of the attributes could have been the history for which that document was used. If Ralph sorts according to the history of his document usage and searches for his research paper, all the documents associated with that research paper would show up. In this manner, metadata tags greatly reduce not only search time, but also the frustration of looking for missing documents. The key now is how to visualize those results in such a way that users can quickly scan through their digitized documents and find what they want efficiently.

### 2.3.2 EFFECTIVE VISUALIZATIONS

There are two important aspects of the digital sorting system that necessitate effective visualizations, piling and activity histories. Both will require the effective use of metadata to categorize the files and appropriately display them to the user.

## PILING

Physically, piling refers to the stacking of papers on top of each other in both an organized and unorganized manner. Digitally, piling is similar to that in the physical world, but in a computer system people stack files on top of each other in any manner they choose, similar to a study performed by Mander et al (1992). In order to find items within the piles, the ‘document pull-out’ method designed by Mander et al seems the most effective and similar to the way a worker would do it in the physical world (Image 5). The ‘document pull-out’ method shows a pile of files such that the one the user has selected is jutting out to the right of the pile connected to a zoomed in image of it. The document still visually maintains its location in the pile as it appears only partially pulled out along with the use shadows to indicate its height above the bottom of

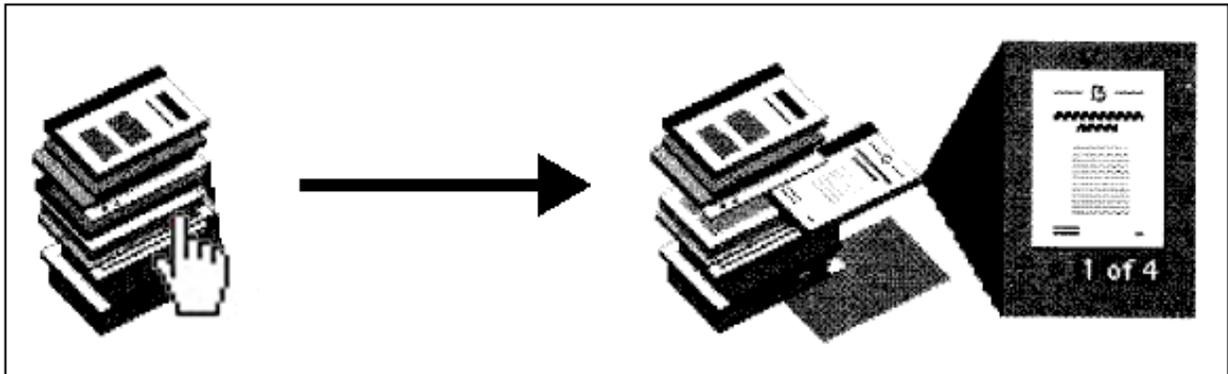


Image 5: Digitally retrieving a particular document out of a large pile (Mander et al 1992)

the pile. 3D-PO could incorporate these types of visualization techniques by sorting the files, using the metadata, into piles and then when the user wants to find a document within one of

those relevant piles, the document pull-out method could be employed to quickly scan through a large grouping of piles.

Another possible way to visualize the groupings of documents would be to use zooming similar to the system Pad++. After the computer sorts the files according to the metadata category specified, they will display as large groups of thumbnails that are piled onto and around one another. This is where zooming comes in. As Bederman et al explained with Pad++, the computer screen becomes similar to stretchable rubber whereby everything you need and do is on this one sheet of computer screen (Bederson, Hollan, et al 1996). Zooming effectively is stretching that rubber to the area you want to view. As the user zooms in, the thumbnails of the files become larger and the details of what those files are becomes more readable. 3D-PO can use this zooming effect to shift the focus of the computer screen to a set of files sorted by the metadata and relevant to what the user desired. Thus the user has effectively seen the visualization of a large group of files and zeroed in on the files relevant to his work.

## ACTIVITY HISTORIES

In 3D-PO we want to be able to track the history of a document to complement the piling so that users can have access to the rich history documents contain. For instance, the history of a document may reveal what piles it has been in, who has touched it, what projects it was used for, or when it was trashed. Many systems have looked at how to recreate this history and 3D-PO will have a very rich history to search.

Edit Wear and Read Wear is a system that enables users to graphically depict a computer file's history according to how much the document has been read or edited (Hill and Hollan

1992). The more a document has been read or edited, the longer the graphical horizontal line extends to the right. In this way, users can quickly scan which documents have been used the most. 3D-PO can use this sort of visualization to allow users to see which files have been read the most or which files have been referenced the most. This will help, for example, when writing a research paper and searching for which documents have been used the most by oneself or by others in the office.

A second effective visualization style that 3D-PO can incorporate is to be able to go back in time and access documents that may have been thrown away on purpose or accidentally. The Time Machine Computing system saves the state of a computer desktop at any given point in time so that it can be accessed in the future (Rekimoto 1999). This way, if necessary, users can refer back to previous states of their desktops in case they need a file that used to be there. One of the additions that 3D-PO will offer to the Time-Machine Computing system is that instead of the computer desktop state being saved, the state of the physical desk and overall office environment will be maintained. This way, when a physical file is thrown away, the digital version of it is still maintained even though the file no longer exists in the office. 3D-PO will then allow someone to search for the file digitally using piles and metadata to be able to either reprint it or read it on their computer.

## 3 METHODS

### 3.1 EXPERIMENTAL PARADIGM

In order to conduct our experiment we studied office workers in their everyday office environments. Once subjects were selected from the Cognitive Science Building on the University of California, San Diego, a preliminary office interview was conducted. This allowed us to gain an understanding of the nature of their job function, their work preferences, typical behaviors, and how they have organized their office. This interview was digitally recorded while still shots captured interesting aspects of their office organization. Following this interview we created two methods for capturing the activity that occurred in the offices. The first involved placing cameras in the ceiling that captured and monitored the interaction of the worker and their personal office space. Recording this coordination allowed us to observe how the user's workflow was shaped and reflected by the evolution of the physical layout of their office space. Additionally, with our recording system we were able to capture how different workers were affected by interruptions and errors that are caused by either natural events or planned stimuli. The second type of method for capturing data was to have subjects take digital pictures of their workspace at certain times according to a picture checklist we provided them with. The day after each day of video recording or subject-taken digital snapshots, a follow-up interview was conducted to gain a better understanding of the subject's work styles and office organization. During the days in which video was recorded or pictures were taken, the office workers completed subject-filled logs in which they told us a story about any errors and interruptions that occurred. From this data, we have begun to derive conclusions to establish whether a user distinction such as "Neats" and "Scruffies" can be made, which will help further the design of a portable desk that is integral, invisible, and natural to the user.

### 3.2 THE TOOLS WE WILL USE

- 1) Digital Camera: When we were surveying our subject pool during the preliminary office interview, we took still shots of our users' office environments to help ensure that we have a wide array of user types and organizational preferences.



Image 6: Subject Taken Picture



Image 7: Subject Taken Picture

- 2) Wireless Video Camera (4): Mounted on the ceilings above our subjects' desks, these cameras provided us with an aerial view of people's primary workspaces. The video and sound captured from this camera was sent to a VCR in a nearby room for recording.

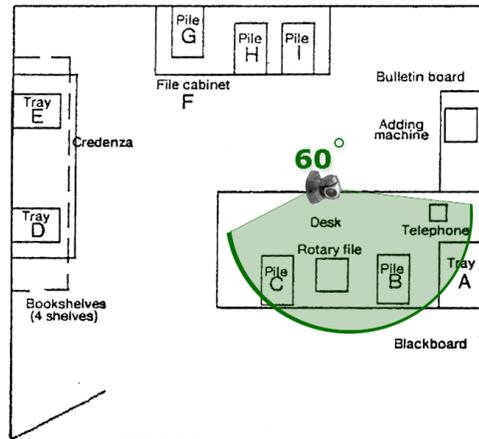


Figure 1: The view provided by our desk cameras.

3) Wide-Angle Wireless Video Camera (4): Each of these cameras was mounted at a strategic corner of the room which allowed us to survey how the office dweller made use of their filing cabinets, shelves, and drawers that were not in close proximity to their desks. Additionally, by providing us with a wide-angle view of the office environment these cameras allowed us to monitor incoming visitors and inflow and outflow of office materials.

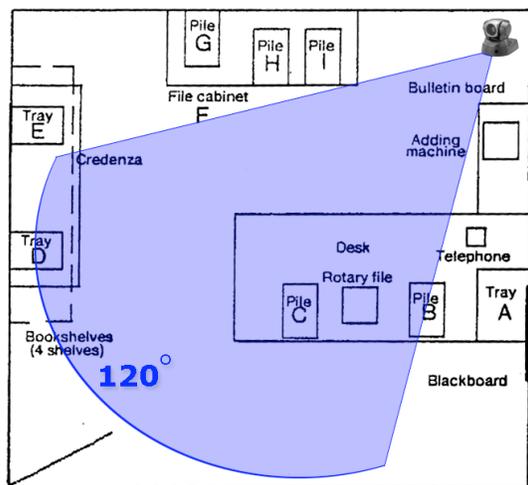


Figure 2: The view provided by our ceiling cameras.



Image 8: Low-Resolution Ceiling view

- 4) Digital Video Camera (1): To digitally record our preliminary office interview as well as the follow-up interviews we used a digital video camera to record this.
- 5) On/Off Switches (4): Subjects were able to easily turn off the monitoring setup in their office for privacy purposes.
- 6) VCR (4): VCR's were used for recording the video and audio output of the ceiling mounted cameras.

### 3.3 SUBJECTS

#### 3.3.1 WHO TO RECRUIT

Our study investigated office workers whose daily tasks revolved around the use of their desk and overall office environment for the entire working day. Office workers who fell into this category were located in the Cognitive Science Building offices on the University of California, San Diego campus. Because they were heavily dependent on utilizing their office environments to complete their tasks, these particular workers were ideal candidates for investigating how people utilize their activity space. The everyday work accomplished in these workers' environments in the Cognitive Science Building is the result of their rich interactions with their office context.

#### 3.3.2 HOW TO RECRUIT

In order to recruit office workers to be subjects for our study, we ensured that these workers had a clear understanding of the importance of their role and the overall aim of the study. Following the description of the project, we explained that we are going to monitor and record their activities using a ceiling camera above their desk and a wide-angle camera mounted in a corner of their office. To account for the possibility that they felt that we are intruding upon their privacy, we clearly explained the three measures we will take to ensure their privacy. First, we showed that the camera can be turned on and off at their own discretion. If an office worker needs to have a private conversation, they can easily turn off all of the monitoring equipment to achieve full confidentiality. Secondly, we showed them a sample video recording of a similar office setting where privacy was maintained since it is not possible to read the content of the

papers on the desk or view specifically what is on the computer monitor. In this way, our subjects would not feel threatened that we are unethically looking through their personal files and belongings. Thirdly, anonymity is preserved in the video, as it is not possible to identify a person's face from the top-down view that we are exploiting with the wireless video cameras above their desktops. Because of the measures taken to protect the confidentiality of the office environment, our subjects were assured of their privacy.

Subjects also needed to sign the necessary consent forms. The UCSD Video Recording Release Consent Form, the UCSD Audiotape Recording Release Consent Form, and the UCSD Photographic Release Consent Form are required for the subjects to be observed and photographed. In addition, the UCSD Audiotape Recording Release Consent Form served a dual purpose, as it allowed us to conduct interviews of the subjects.

### 3.3.3 HOW MANY SUBJECTS

Our study used two office workers for video recording and one for digital stills from the Cognitive Science Building on the University of California, San Diego campus. Each subject was recorded eight hours a day for five days spread out over the course of two weeks.

Additionally, two other subjects collected digital stills while another four subjects allowed us to interview them to gain an insight into how they worked.

## 3.4 PROCEDURES

### 3.4.1 CAPTURING CORRECT WORKERS

Before administering any user studies and tests, we took snap shots of our subjects' workspaces with a digital camera. We captured aerial views of these work environments as well as taking close-up shots where information and office mechanisms were concentrated. Additionally, our photos illuminated the contents and usage of hidden information storage areas such as filing drawers, cabinets, and shelves. Gathering these snap shots of our office dwellers' activity spaces before we set up our monitoring and recording systems, provided us with time to ensure that we were studying a well balanced group that consists both of workers who maintain superficially tidy spaces as well as workers who keep a messy workspace. Compiling a collection of snap shots of these office environments enabled us to confirm that we have enough tidy and messy workspaces to analyze. Establishing this process for gathering a prerequisite assortment of workers who inhabit tidy and messy office environments, forced us to verify our user selections before we spent a great deal of time and energy setting up our extensive monitoring and recording system.

### 3.4.2 OFFICE TOUR – PRELIMINARY OFFICE WORKSPACE INTERVIEW

Following the preliminary office workspace assessment, we used the principles and methods of contextual inquiry as described in *Contextual Design* (Beyer, Holtzblatt 1998) to conduct videotape interviews with each of our subjects in order to see how they physically structure their office. Prior to the actual interview, we stressed that this experiment is not a worker efficiency study but rather just an observation of how different types of people employ different methods to

accomplish their tasks. We observed the worker's strategies for moving through their office environment to accomplish tasks as well as probe them for reasoning and explanation as to why they work in the manner they do. In this way, we will employ the Master/Apprentice Model of contextual design where we as the apprentice attempted to learn from the worker about the strategies involved in their everyday work.

The Office Tour Questions document (See Figure 3) details the types of questions we will ask, such as "What is in that pile/ file?" or "Why is information located in that particular place?" Following the questions about what or why information is in a certain place, were task-based questions where we asked the subjects to find artifacts that structure their workday. These artifacts include finding computer instruction manuals, a particular file or book tailored to the worker's function, a phone directory, Post-It notes, a trash can, a radio, a calendar or day planner, writing instruments, paper clips, a stapler, and food. The last part of the interview consisted of understanding how the subjects prioritized their daily schedule, whether it was through input/ output trays, artifacts on the desk, exogenous entry points (i.e. walk-ins, phone calls, email, physical mail), or their calendar/ day planner. Once the interview was complete and we had gained an understanding of the office worker's strategies, we began to figure out the structure of the desk and overall office, which greatly aided us later when we observed the captured video of their actual work.

### 3.4.3 CAPTURING OFFICE ACTIVITY — SURVEILLANCE CAMERAS

The first of two methods to capture our subject's activities was through the implementation of surveillance cameras. One wireless cameras was placed directly above the worker's primary workspace where most of their daily activity occurred while a second wireless wide-angle

camera was placed strategically in the corner of the room to monitor all the activities that occurred in the office. Both cameras were attached to a power strip with an ON/OFF button so that our subjects could easily turn the cameras on and off at their own discretion. This gave them the power to control what gets recorded and what does not thus allowing them to maintain their privacy. The wireless camera receivers were located in another office and were linked to a VCR that recorded the output of the wireless cameras and were programmed to record on the appropriate days and times.



Image 9: Low-Resolution Ceiling view of Office

#### 3.4.4 CAPTURING OFFICE ACTIVITY – DIGITAL SNAPSHOTS

The second of the two methods involved having the subject take digital snapshots of their office environments according to a picture checklist (See Figure 4). This option was given to workers who chose not to have the surveillance cameras record their daily activity. The picture checklist included taking digital snapshots at such times as before and after lunch, before leaving for the day, or whenever a pile is created or moved. The checklist also informed the subject as to what to

take pictures of such as desk surfaces, filing cabinets, or input/ output trays. This checklist provided them with the structure to allow them to easily take pictures of interesting occurrences in their offices.

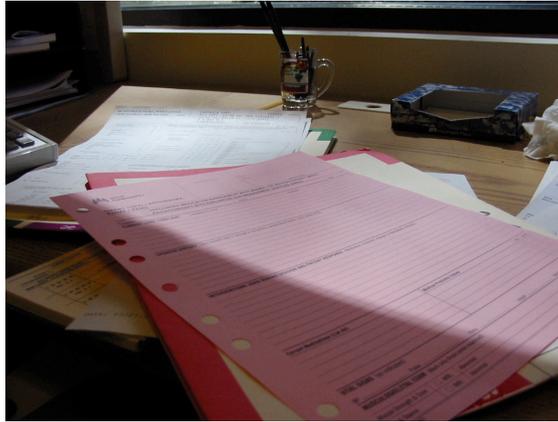


Image 10: Subject Taken Picture

#### 3.4.5 SELF-REPORTED ERROR LOG & SELF-REPORTED INTERRUPTION LOG

Interruptions and errors, both exogenous and endogenous, frequently occur throughout people's workday. These interruptions and errors disrupt the current task causing the worker to alter the structure of their activity space to match the new task. During the worker's day at the office, we asked them to fill out the Self-Reported Error Log (See Figure 5) in which the subjects reported as many errors as he or she can remember. These logs served as pointers to when interesting events happened in our digital recordings. They helped us understand what actually happened, when and how it happened. With the Error logs we asked our participants to tell us a story of what went wrong or what happened unexpectedly. There were three sections to fill out, first they told us a story about what they were trying to do, what the error was, and what was going on at the same time, secondly they filled out why they think the slip occurred, and lastly, they were asked to record when they realized they made an error and what did he or she do about it. The

types of errors were categorized into encoding errors, retrieval errors, artifact malfunctions, and coworker errors. Within each of these errors, are specific errors that can be classified into these categories. For instance, an encoding error occurs when a file is stored in the wrong section while a retrieval errors happens when the subject could not find the file they were searching for. An example of an artifact malfunction is if the battery on the clock dies, while an example of a coworker error is if a coworker misplaces a borrowed book that the subject needs to complete a task.

The Self-Reported Interruption Log (See Figure 6) helped us determine how our subjects handled interruptions and how they recovered from them. In this log, there were seven brief sections to fill out, centered around giving us an understanding of what happened, what they were doing before the interruption, what they did after the interruption, and did something useful come from the interruption. The types of interruptions were divided into two types, endogenous interruptions (i.e. checking email, turning on the radio, taking a snack break, or surfing the Internet) and exogenous interruptions (i.e. visitors asking for help, visitors bringing requested information of file, an incoming phone call, or an incoming fax).

Using both the error and interruption logs, allowed us to quickly sort through the videotapes in order to skip ahead to places in the recordings where we knew there were errors or interruptions to observe by using the approximate start and end times. Once we were at the specified interruption or error, we also knew what was occurring in the office because the subjects filled out what type of interruption was happening. In this way, using the subject's input, we did not have to guess what was going on in the video. We did not rely on the use of error and interruption logs but rather let them aid us in understanding the activities we view in the videos.

#### 3.4.6 FOLLOW-UP INTERVIEWS

Once our Preliminary Office Tour was complete we conducted an additional 5 half hour interviews either in the middle of the day or at the end of the day. The questions were similar to the preliminary interview but these interviews concentrated more on specific activities that occurred during the day. Each of these interviews was conducted the day after a recording was complete. Three mid-day interviews, administered right before lunchtime, helped us get a feel for how our subjects started their day. The two end-of-day interviews, conducted right before they left to go home gave us a sense of our subject's workday as a whole. Both interviews gave us a better understanding of our subject's work activities as a whole and helped us better understand what occurred in the video recordings.

#### 3.4.7 WEBSITE

The Neat and Scruffy website used the Client Web application designed by the Interactive Cognition Laboratory (ICL) at the University of California, San Diego, in order to facilitate communication amongst group members and allow for the archival of key documents. For the research group to improve communication amongst members, the website will serve as a discussion board where members of the group were able to post announcements, start discussions, and list tasks. In this way, group members were able to refer to the website for questions they had or possible tasks they wished to create. A second purpose of setting up the website will be to store the important documents such as the questions for the interviews as well as the error and interruption logs. Every group member had quick and readily available access to the information.

### 3.4.8 ANALYZING DIGITAL VIDEO RECORDINGS

In order to capture the important events from the video recordings of each subject, a spreadsheet was designed to categorize the subject's actions according to the major categories of what occurs in an office, filing, interruptions, trashing, tasks, piling, usage of coordinating structures, impromptu note taking, leaving and returning from the office, mail, and tidying up (See Figure 7). Each of these major categories was subdivided into more specific actions. For example, in filing, the specific actions were filing away, create file, and access files. Every time each action happened, a tally was used to count up the total number of occurrences. These tallies were recorded per minute that they occurred. If the subject filed away at 11:30am, a tally was marked at that minute interval. This spreadsheet allows us to see the distribution of activity across a workday as well as quickly sum up all of the occurrences of each action.

Once the totals were calculated, the Poisson distribution was used to test the results for significance. This distribution “models the number of random occurrences of some phenomenon in a specified unit of space or time” (<http://stat.tamu.edu/stat30x/notes/node70.html>). Our parameters for the distribution took into account the total number of occurrences versus the average of the totals between the subjects. When the Poisson distribution returns a value exceeding the 95% threshold, the associated values are deemed significant. The following results reflect the significant findings that were returned.

## 4 PREDICTIONS

### 4.1 USER STUDIES

Our hypothesis is that these strategies of worker types, Neat and Scruffy, can be meaningfully placed on a continuum that reflects a primary difference between people who are Neat and those who are Scruffy. The empirical data gathered from our ethnographic study will support this distinction by investigating the number and types of errors, number of files, number of piles, the ratio of files to piles, trashing strategies, and more. Our charts for data analysis and the accompanying test for significance help provided the foundation for which we can make these claims.

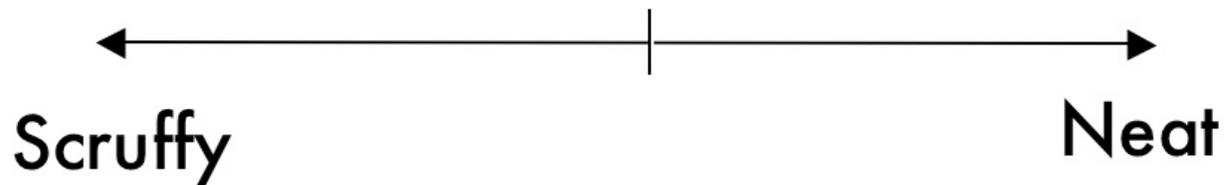


Figure 8: There is a well defined continuum that ranges from Neat to Scruffy.



significance the Poisson distribution took into account the Neater subject's amount of filing across the week, 174, and also used the average between the two subjects, 136. The Poisson distribution returned a value of 99.99%, which demonstrates that our Neater subject's amount of filing away was significant, compared to our Scruffier subject. The average number of times each subject filed away per day is shown in the chart below (See Chart 1). This chart reveals that on average per day, our Neater subject put away files nearly twice as often as our Scruffier subject.

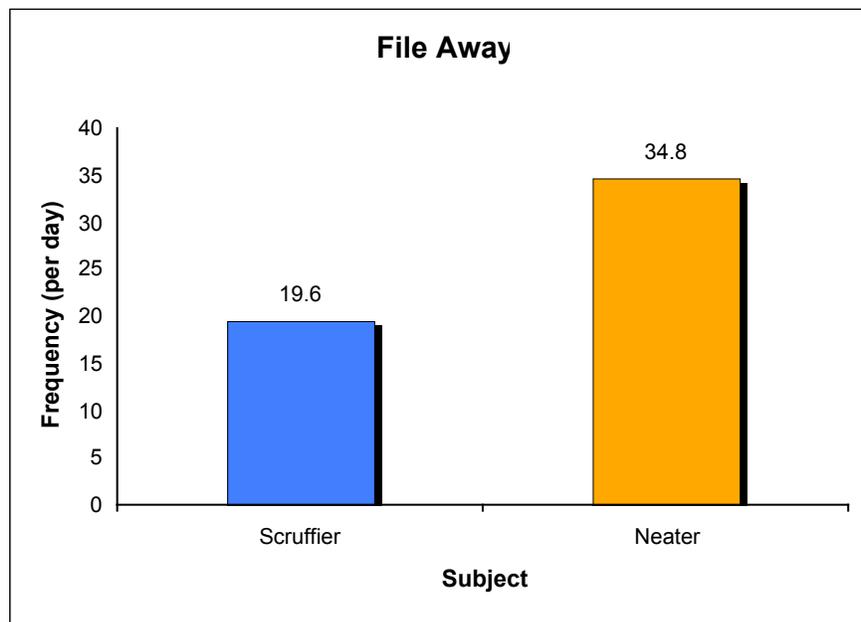


Chart 1: Neater vs. Scruffier – File Away

## ACCESSING FILES

Pulling files out documents from a filing area is referred to as accessing files. This action is important because it shows how much of one's tasks are hidden inside the filing cabinets. Instead of having the files out on the surfaces of the office, the files reside in filing areas that must be

opened and searched through to find the appropriate documents. Again, the data reveals how our Neater subject performs this action with much more frequency than our Scruffier subject, 226 times to only 92. The Poisson distribution returns a value of 99.99%, again showing that the results are significant. Below is listed the average number of times per day that our subjects access files, with our Neater subject accessing files nearly 2.5 times more often than our Scruffier subject (See Chart 2).

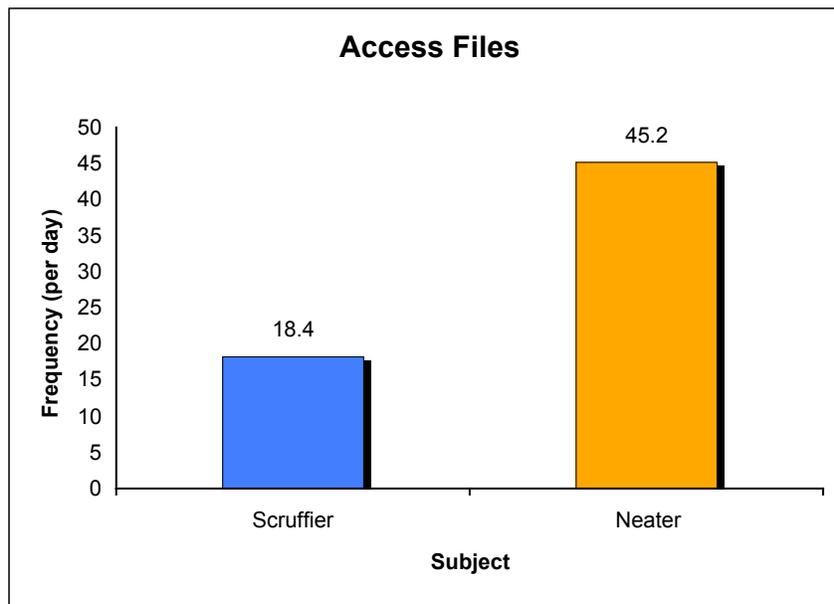


Chart 2: Neater vs. Scruffier – Access Files

One paradox that we found in our data is that our Neater person pulls out files around 10 times per day more than she puts away files. From the last two charts, she pulls out files 45.2 times per day but only files away 34.8 times per day. It is expected that the results would show that she puts away files roughly as many times as she pulls them out, as our Scruffier worker does. So, where did all the paper go? We have hypothesized that the reason for this discrepancy is that occasionally she will pull out files in many instances, combine them and then file them all away in one instance, thus skewing our results. A second hypothesis is that sometimes she will

file away in filing cabinets outside of her office where our cameras were not able to see her thus accounting for the discrepancy.

In the filing activities of filing away and accessing files, our Neater subject dominates performing this particular action compared to our Scruffier subject, executing these actions around twice as often. This is backed up by the results of the Poisson distribution test, which returns results of 99.99% on both activities showing that those actions are indeed significant.

## 5.2 PILING

### MOVING PILES

Moving piles is an element of mobile workspaces, such as documents that can easily be moved from one desk to another or from the top of a filing cabinet to a table. Piles are highly mobile documents. Moving piles is the action of changing the location of a pile not necessarily only to an empty space, but could possibly involve moving the pile on top of another pile.



Image 12: One of the Piles on Scruffier worker's desk

In contrast to the activities of filing, moving a pile is performed over 50% more often by our Scruffier subject than our Neater subject per day. The chart below shows that our Scruffier subject moves piles 29.8 times to only 18 times for our Neater subject (See Chart 3). Once again, the Poisson distribution shows that these values are significant returning a result of 99.99%.

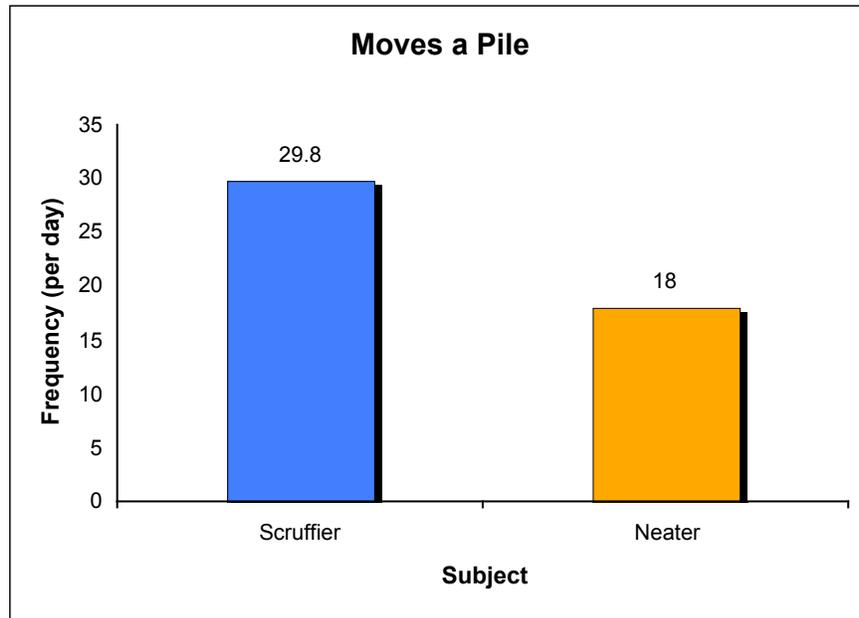


Chart 3: Neater vs. Scruffier – Moves a Pile

## ACCESSING PILES

Grabbing piles of paper on one's desk or surfaces refers to the frequency with which our subjects access piles. This piling activity occurs with much more frequency in our Scruffier subject's office environment than our Neater subject. The total across the week with which our Scruffier subject accesses piles is 118 times while our Neater subject accesses piles 80 times over the five days. The Poisson distribution returns a value of 97.24% showing that our Scruffier subject's

piling activities are significant. The chart below shows that on average our Scruffier subject accesses piles 50% more often than our Neater subject, 23.6 to 16 (See Chart 4). So, again we see that this piling activity is done much more frequent by our Scruffier subject.

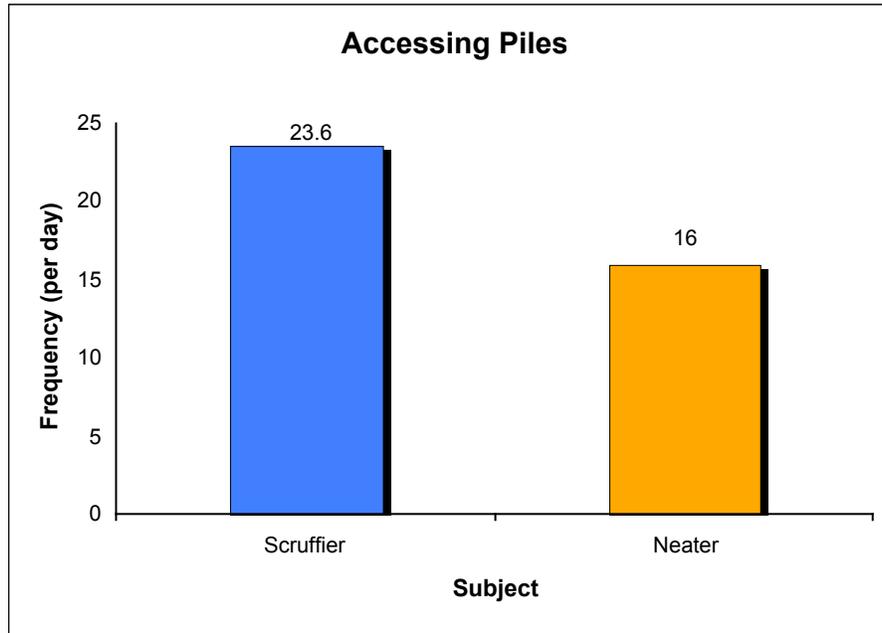


Chart 4: Neater vs. Scruffier – Accessing Piles

### 5.3 ADDING LAYERS

In addition to managing many piles, our Scruffier subject prefers to manage multiple layers as well. Layering refers to placing one pile onto another pile with no desire to merge the two piles, thus layering different activities onto one particular region. The layering of two piles though does not only mean that different tasks are layered into one region. One task may have multiple layers and as each part of that task is completed, that layer gets removed thus making the next layer beneath it visible. These layers are synonymous with a stack in which the last item added is the first item dealt with and removed, a LIFO (last in, first out) method of accomplishing a task.

As each layer is added onto the stack, the previous layers get hidden and only the top layer is visible. When a layer is removed, only the next layer in the stack is visible, the rest are still hidden, thus many piles can occupy the same region of a surface in the office.



Image 13: Our Scruffier subject managing multiple layers.

From the data, our Scruffier office dweller added a layer 99 times over the course of five days while our Neater office dweller added a layer 50 times. Here the Poisson distribution calculates a value of 99.72% denoting this activity as indeed significant. From the chart below, our Scruffier subject adds a layer twice as often per day as our Neater subject, 19.8 times on average per day versus 10 (See Chart 5).

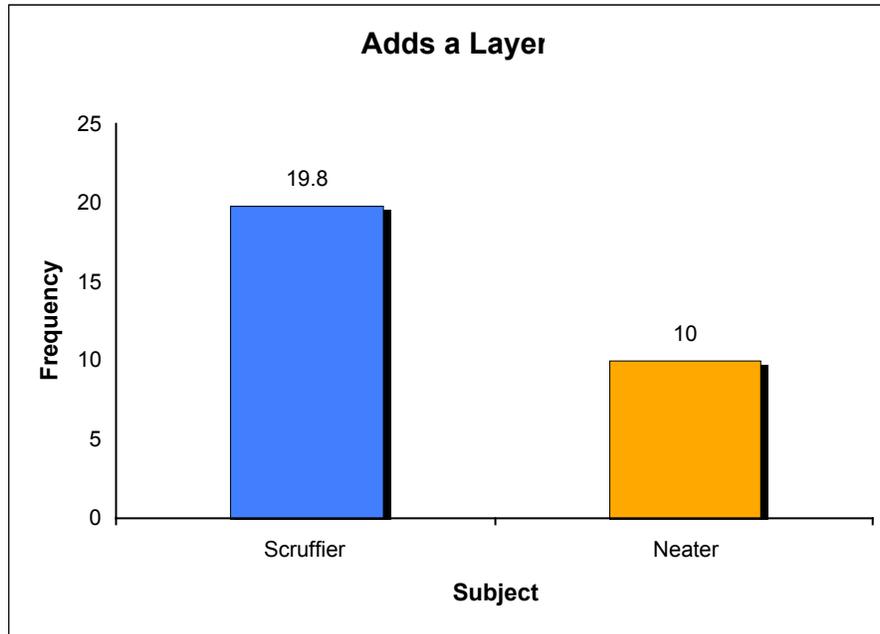


Chart 5: Neater vs. Scruffier – Adds a Layer

Interestingly, from the video recordings and data we noticed that although our Neater subject does add layers, she has a tendency to avoid adding layers to keep reduced layers on her surfaces. In one instance, she avoided adding a layer to her work and created a new surface with which to accomplish her tasks, which was her lap. These different strategies in filing, piling, and layering activities, help distinguish our two subjects.



Image 14: Our Neater subject using her lap to avoid layering.

## 5.4 NUMBER OF TASKS OPEN

The number of open tasks is a good indication of how our subjects prefer to work. Their multi-tasking disposition may relate directly to the amount or frequency of piling activities. Although we did not get significant results, we did see a trend. The implication with the trend that we have found, is possibly that our Scruffier person's office does not look as tidy as our Neater person's because they like to tackle many jobs at once. In order to tally the number of tasks open at once, a count of the number of tasks opened and closed was kept. In this way, we could take the number of tasks open and average across the day. From the chart below, our Scruffier subject has a tendency to have twice as many tasks open at once as our Neater subject (See Chart 6).

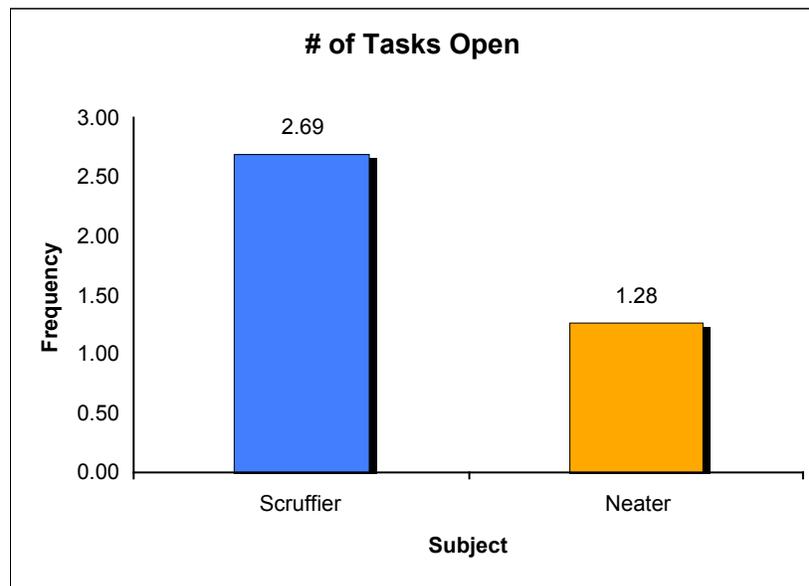


Chart 6: Neater vs. Scruffier – # of Tasks Open

## 5.5 STICKY NOTES

Impromptu note taking devices refer to objects with which each of our subjects take notes on. For example, notepads and scrap pieces of paper are examples of impromptu note taking devices, but the type that we found to be most significant, were the widely used Sticky Notes. Our subjects had strong opposing feelings about these highly mobile notes for jotting down info quickly. Our Scruffier office dweller was a big fan of sticky notes, in one of our interviews, she proclaimed “I am the Post-It queen...I use more Post-It’s than anybody.”

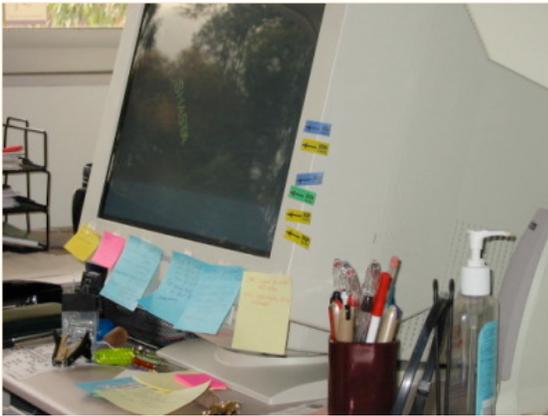


Image 15: Sticky Notes on a Scruffier worker’s monitor

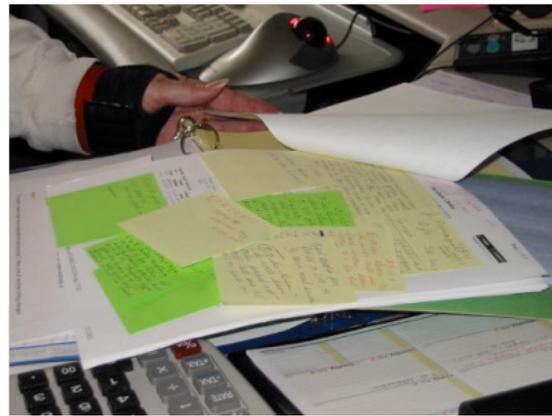


Image 16: Scruffier Subject’s Layered Sticky Notes

On the other hand, our Neater friend was the complete opposite. Sticky notes were a rarity in our Neater office dweller’s workspace. From her preliminary interview she stated, “I hate stickies...I think they look so messy.”



Image 17: Absence of Sticky Notes in Neater's space



Image 18: No visible Sticky Notes in Neater's office

Given their strong positions on using Sticky Notes, we were not at all surprised to see our Scruffier Office Dweller either refer to or create these impromptu note-taking devices 4 times as much as our Neater Office worker (See Chart 7). The Poisson distribution calculates a value of 99.91%, informing us that the data we received regarding on our Scruffier subject's use of sticky notes was significant in comparison to our Neater subject.

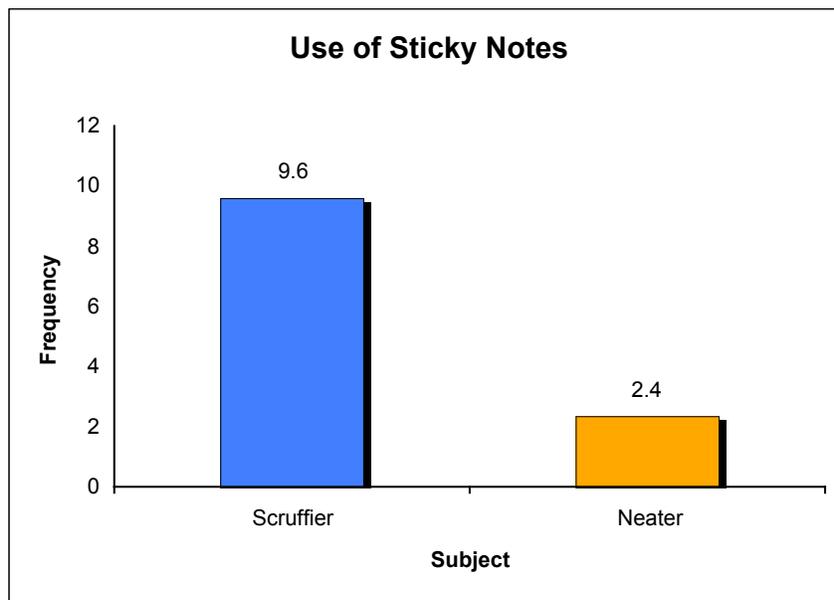


Chart 7: Neater vs. Scruffier – Use of Sticky Notes

## 5.6 MOBILE WORKING SPACES

The larger issue at hand here is the preference for a mobile working space. One of the key attributes of sticky notes is that they are easy to move around the office and attach to different documents or surfaces. Information written on these impromptu note-taking devices is highly mobile and over the course of a week a sticky note can move from a pile of papers to the monitor screen to a filing cabinet and then to a folder on the other side of the room. Looking at how many times an office dweller moves piles in a day is another way of looking at whether a person's work frequently moves from one region of their office to another. When a person moves a pile they are moving part of their activity to another location in their office. When we combine the number of times our subjects used Sticky Notes with the number of times that they moved Piles we see that our Scruffier Subject does these activities almost 2 times as much as our Neater one (See Chart 8). Again, using the Poisson distribution, we find that our Scruffier subject's use of these mobile working spaces is significant, returning a value of 99.99%. Connecting this to our findings that our Scruffier Subject handles more tasks at once, one possibility for the more mobile working space is that our Scruffier Office Dweller needed to move and reorder information in their space to help focus their attention on one of many open items in their office space.

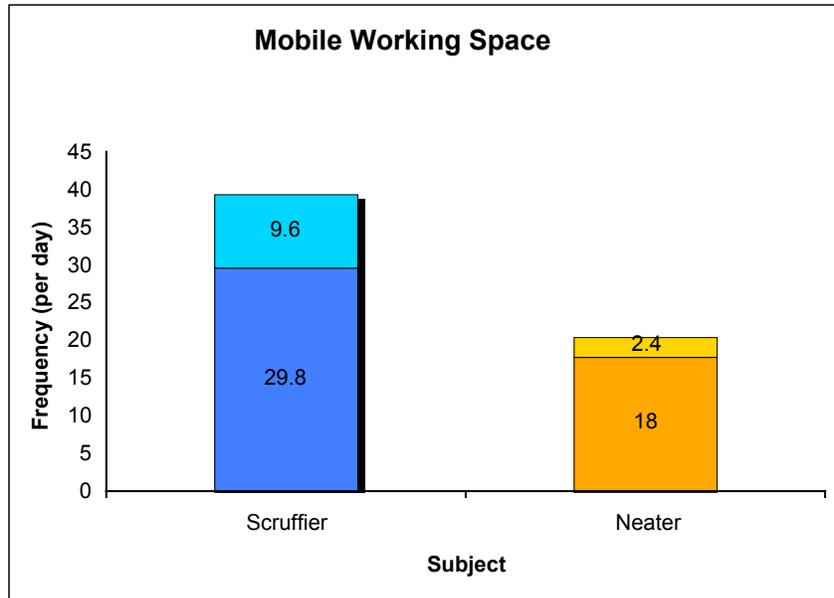


Chart 8: Neater vs. Scruffier – Mobile Working Space

## 6 CONCLUSIONS

Using the empirical evidence gathered from counting the key actions occurring in the 80 hours of video we collected from two subjects in their offices, we have been begun to place these two office dwellers on our Neat and Scruffy continuum. Comparing our two subjects' averages per day when performing such activities as filing, piling, managing layers, and using sticky notes as well as their differing preference for the number of tasks they keep open at once allows us to place our Neater subject further right than our Scruffier one on our continuum (see Figure 9). Our study has lead us to several conclusions.



Figure 9: We can place our 2 office dwellers whose office spaces we videotaped on our metric-less continuum.

At this point our study has served its purpose as a successful pilot. We have been able to distinguish a Neat office dweller from a Scruffy one not only with our intuitive notions, but with the support of empirical factors. Our video data analysis has supplied us with the empirical basis necessary to make this distinction for these two office dwellers according to our specified criteria. The empirical differences between these two subjects we recorded in our filing, piling, managing layers, and using sticky notes categories were indeed significant according to the Poisson distribution. Even though our findings with the number of tasks our subjects kept open at once did not turn out to be significant, we did notice a trend in which our Scruffier office dweller preferred to keep almost twice as many tasks open at once. Hopefully, future studies will be able to obtain more significant findings compared to our pilot study in order to investigate variations in preferences for keeping many tasks open at once between Neat and Scruffy office workers. As a pilot study our project has been successful because we have obtained for the most part significant findings that enable us to distinguish between the two subjects we digitally recorded with real world observations.

Our 3-pronged approach to studying the complex world of the office dweller also proved to be successful. Interviewing our subjects with prepared questions was useful for obtaining a detailed account of how our subjects worked in their offices. These questions helped us place our office dwellers' work in context as they provided us with the opportunity to learn about our subjects' job function, their work preferences, typical behaviors, and how they have organized their office. Asking our subjects to fill out both Error and Interruption logs was helpful for analyzing our digital video recordings because these activity logs allowed us to connect sequences of actions into a larger story. Requesting some of our subjects to take digital pictures according to a picture checklist we provided them with aided our comprehension of how these subjects work spaces looked when they were immersed in common office activities. Recording our office participants' workspaces with low-resolution ceiling cameras proved to be an effective manner to collect quantitative data about how people actually work in their office environments, while still respecting their privacy and the security of their documents. Taken as a holistic approach, these data collection methods provided a strong foundation for analyzing what takes place in the interaction between people and their office spaces.

We are aware of the limitations of our Neat and Scruffy scale as we only recorded two subjects with video. Because of these limitations we are not able to create a precise metric on our map to locate office dwellers exactly. Right now we can only say that we have a Neater subject who is placed further to the right on the continuum than our Scruffier subject. A more precise metric will naturally be more warranted as the subject pool for recording video increases. Developing the criteria for this metric will pose an interesting question for future work on this project.

## 7 FUTURE WORK

While our study at this juncture has offered some empirical evidence to support the notion that office dwellers have a diverse array of work preferences and strategies for organizing their office, it is important to keep in mind that it is only the beginning. Our study has just scratched the surface of the complex world of the office dweller with our Neat and Scruffy distinction. As we were collecting our data for the first phase of this project, *Understanding Today's Office*, several ways we could improve our methodology surfaced.

### 7.1 PARTICIPANT/ OBSERVER METHOD

Although we did get a detailed account of how our subject's worked from our Interviews, one way we can improve our study is by employing the Participant/ Observer method as well as Contextual Inquiry (Beyer, Holtzblatt 1997). Using these methods will enable us to gain a deeper understanding of our subjects' job function because we will be able to investigate how our office dwellers work in their office spaces while they are actually submerged in their real activity. Fostering a Master-Apprentice relationship in which our subjects teach us how they prefer to work and structure their office (Beyer, Holtzblatt 1997) is advantageous over simply interviewing our subjects after the fact because we will be able to uncover and fully understand their difficulties and everyday strategies which they are either not conscious of or do not report. This relationship also advances us beyond watching digital video recordings in isolation without knowing our office dweller's work context.

## 7.2 REVIEWING VIDEOS

Reviewing our video capturing with our office dwellers would have been ideal if we were not constrained by time. This supplement to our method of counting all of the key actions taking place in our videos would help us gain a better understanding of our office dweller's intent for those actions. For example, reviewing a video sequence where a great deal of paper is constantly being moved and organized will help us clearly decipher all of the actions that our subject is performing as well as understand why they are being performed. Going over action-filled sequences will help us see the larger picture since we will be able to connect individual actions such as adding paper to an existing pile to the larger task at hand, possibly preparing a financial report. Additionally, reviewing video data with our subjects makes up for our low-resolution cameras which for privacy issues prevent us from seeing the content of documents which in turn make it difficult to know exactly what task someone is working on.

## 7.3 CONTROLLING FOR JOBS

When determining what office subjects to select for our study we did not pay attention to their job function. However, controlling for differences in jobs and tasks would have been beneficial because our data collection would take into consideration the varying amounts of paper and workflow that accompany different professions. For instance, future studies could benefit from comparing the office environments of two accountants, rather than comparing the workspace of one accountant with one human resource personnel. Considering job function improves studies of office ecologies because it accounts for the influence of task parameters on both office dwellers and spaces.

## 7.4 TRACKING LIFE HISTORIES OF DOCUMENTS

Tracking the life history of documents will improve our profile of a particular office dweller's work style. This will also let us map the regions of activity in a person's office space, which will help us predict how workflow is mapped onto the spatial environment. Knowing how often incoming documents reside in certain locations on a person's desk provides us with some more insight on how our office dwellers have both consciously and unconsciously organized their work space. Following the life history of documents will further our understanding of office ecologies because we can construct a diagram of any given subject's office highlighting how often paper enters certain regions and also how long it remains there before it is either moved to another region or sent out of the office environment. This diagram will provide us with an empirically meaningful chart to help us make claims about how often our office subjects use certain surfaces or filing cabinets and also hypothesize what types of activity are frequently tackled in those areas. A powerful information visualization resulting from a close following of the life history of documents in a given subject's office will also help us establish what is the normal persistent state of their office ecologies which they both feel comfortable with and tend to gravitate to from different beginning states of either high structure or high disorder. In other words, this methodological improvement to our study will help us deduce the degree of clutter that usually appears in particular regions of our subject's office ecology.

## 7.5 EMOTIONAL INVESTMENT

One thing that became apparent from our interviews with our office dwellers was that people became attached to maintaining a certain aesthetic and structure to their office. We also noticed

that people find strategies that work for them in their office environments, which become habits that they do not feel comfortable breaking. Because people work in their offices for many hours everyday they invest part of their Emotional Self when they structure and organize their workspaces to their desired preference. For example, one of our office subjects was strongly opposed to using sticky notes, one of the most common impromptu note taking devices, because they felt these often times bright and colorful notes did not look attractive. If this particular office worker left their office for a few minutes and a coworker came in and stuck several bright purple notes on their computer screen to communicate important information, this subject would be somewhat shocked about these attention grabbing reminders when she returned to her office. These sticky notes would seem very intrusive to this subject and would cause some discomfort to them because they have expended much time and energy to ensure that their office meets their aesthetic standards. People become emotionally attached to their preferred office organization and appearance. By considering this attachment future studies can introduce a new element to the equation of what factors and parameters affect office ecologies. Considering people's emotional investments will also shed further light on why subject's workspaces appear the way they are. It will also advance predictions of how office dwellers will uniquely respond to different types of input to their offices.

## 7.6 ACCOUNTING FOR THE DIGITAL WORLD

Although there is a belief that we are moving towards a paperless office works such as *The Myth of the Paperless Office* (Sellen & Harper 2001) help illuminate the fact that paper is still a huge reality in our everyday lives. Office dwellers continue to write on forms, create new folders, and print multiple documents. But as we were conducting our study we did notice our office dwellers

working on their everyday tasks in the digital world, namely the desktop computer. We could further our understanding of office ecologies if we considered how the digital world is coordinated with the physical world. Studying this coordination will give us a new appreciation for our subject's tasks that are completed strictly in the digital world. We will also be able to sharpen our count of how many tasks a person prefers to juggle at once since we can include the work done on the computer. However, there are definite privacy issues that need to be resolved if a person's everyday activity on their computer screen is going to be recorded. Unlike the physical world, which we can monitor with our low-resolution cameras effectively, while still preserving our subjects' privacy, monitoring the digital world presents a bigger challenge. It is difficult to record activity on the computer screen at low resolutions and still ensure that people's digital activity will be easy to identify. Once this privacy issue is handled, future studies will benefit by capturing how the digital and physical worlds are coordinated in office dweller's information rich everyday lives.

## 8 FINAL THOUGHTS

To conclude, our project has just scratched the surface of the complex world of the office dweller with our Neat and Scruffy distinction. Our pilot study has just begun to provide some of the real world studies of people working in their office environment that are necessary to develop the user-centered digital supports that advance us closer to our goal of a Context Aware Office. Our methodology as well as our suggestions for future work will undoubtedly bring us closer to enhanced office workspaces that will improve the everyday lives of all office dwellers irrespective of their position on the Neat and Scruffy scale.

## REFERENCES

- 1) Abowd, G. D., Mynatt, E. D., Charting Past, Present, and Future Research in Ubiquitous Computing, ACM Transactions on Computer-Human Interaction, Vol 7, No. 1, March 2000, pp 29-58.
- 2) Bederson, B., et al., *Pad++: A Zoomable Graphical Sketchpad for Exploring Alternate Interface Physics*, Journal of Visual Languages and Computing, 1996, Volume 7, pp 3-31.
- 3) Beyer, H., Holtzblatt, K., *Contextual Design: Designing Customer-Centered Systems*, San Francisco, 1998.
- 4) Dey, A. K., *Understanding and using context*, Personal and Ubiquitous Computing, Vol 5, No. 1, pp 4-7, 2001.
- 5) Dey, A.K., Abowd, G., Salber, D., A Conceptual Framework and a Toolkit for Supporting the Rapid Prototyping of Context-Aware Applications, Human-Computer Interaction, Vol 16, pp 97-166.
- 6) Harper, Richard H.; Sellen, Abigail J. *The Myth of the Paperless Office*. MIT Press, 2001.
- 7) Hill, W.C., Hollan J.D., Wroblewski, D., and McCandless, T., Edit Wear and Read Wear, In Proceedings of ACM CHI '92 Conference on Human Factors in Computing Systems, 1992, pp 3-9.
- 8) Kirsh, D. (2000). A Few Thoughts on Cognitive Overload, *Intellectica*, CNRS. 30, 19-51.
- 9) Kirsh, D. (2001). The Context of Work. *Human Computer Interaction*, 2001.
- 10) Malone, T.W. (1983), How Do People Organise Their Desks? Implications for the Design of Office Information Systems. *ACM Transactions on Office Information Systems* 1(1) pp.99-112.
- 11) Mander, R., Salomon, G., Wong, Y. Y., A Pile Metaphor for Supporting Casual Organization of Information, *CHI*, 1992.

- 12) Moran, T. P., Dourish P. Introduction to This Special Issue on Context-Aware Computing, *Human-Computer Interaction*, Vol 16, No. 2-3, 2001.
- 13) Rekimoto, J., *Time-Machine Computing: A Time-centric Approach for the Information Environment*, UIST'99.
- 14) Silberman, S., The Hot New Medium: Paper. *Wired*, Issue 9.04, April 2001.
- 15) Tyson, P.J. (1992) The Desk as a Social Institution. Technical Report EPC 1992.
- 16) Vaduva, A., Dittrich, K. R., Metadata Management for Data Warehousing: Between Vision and Reality, 2001 International Database Engineering & Applications Symposium (IDEAS '01), 2001.
- 17) Weiser, M., The Computer for the 21<sup>st</sup> Century, *Scientific American*, 1991.
- 18) Weiser, M., *Some computer science issues in ubiquitous computing*. *Communications of the ACM*, 36(7):75--85, July 1993.

## FIGURE 3 - OFFICE INTERVIEW QUESTIONS

- 1) Visitor/ Coworkers
  - a. Who visited you this morning?
  - b. What time did he/ she arrive?
  - c. How long did they stay?
  - d. Did you have more than one visitor at once?
  - e. Was that visitor expected?
  - f. Did they give you and paper documents or other items?
    - i. Which ones? Please point them out.
  - g. Did you pull any documents out of your files or off your desk for them?
  - h. What were you doing when he/ she came in?
  - i. Were you in the middle of something when they came in?
  - j. Did their visit cause you to switch tasks?
    - i. If so, do you remember the task that you were working on previously? Did you go back to your original task once you were done with the visitor's task?
  - k. After the coworker came in, did you have to leave the room?
- 2) Telephone Calls
  - a. Did you receive any non-work related phone calls today?
    - i. Was that phone call expected?
    - ii. What were you working on when that phone call came in?
    - iii. Did that phone call disrupt your work?
    - iv. Once the phone call ended, did you go back to your original task or begin a new task?
  - b. Did you receive any work-related phone calls today?
    - i. Was that phone call expected?
    - ii. What were you working on when that phone call came in?
    - iii. Did that phone call disrupt your work?
    - iv. Once the phone call ended, did you go back to your original task or begin a new task?
  - c. Did you make any phone calls today?
    - i. How did you know what number to dial?
      1. Speed/ Memory dial?
      2. Phone book?
      3. Directory Listing?
- 3) Filing
  - a. How did you find that file? (point to a file on the desk)
    - i. Where was it located?
    - ii. Was it located where you thought it would be?
    - iii. Did you have any difficulty finding the file?
    - iv. How long did it take for you to find the file?
  - b. Where did this paper go (trash, filing cabinets, desk, coworker, fax tray)? (point to a file in a picture)

- i. Why did you put the file away?
  - c. Look in the fax machine holder
    - i. Why did you leave the originals in here?
- 4) Breaks
  - a. What were you doing before/ after your lunch break?
  - b. What time did you take your lunch break?
  - c. Did you do work during your lunch break?
  - d. Did you take a break in the middle of a task or was the task completed?
- 5) Trashing
  - a. Did you throw away any documents or papers from your desk?
  - b. What items have you thrown away today?
  - c. Did you throw away any items no longer needed for a task?
- 6) Morning Questions
  - a. How do you know what tasks you need to work on today?
  - b. What are you going to do today?
- 7) Leaving the Office
  - a. What time did you get the mail today?
  - b. Was there a lot of junk mail today?
  - c. What did you trash?
  - d. Was any of the mail related to your work for today?
  - e. Did you have to make any copies today?
  - f. Did you consult a coworker for help?
- 8) Mail
  - a. Did you collect your mail today?
  - b. When do you usually check your mail?
  - c. About when did you collect your mail today?
  - d. Did you bring it directly to your office?
  - e. Did you sort the mail at your box?
  - f. Do you check your box more than once a day?
  - g. How many times did you check your mail today?
  - h. Do you have a normal place you sort your mail?
  - i. Did you use that place today?
  - j. Did you get mail that did not belong to you?
  - k. How do you normally look at your mail?
- 9) Things to Notice in Room
  - a. Why do you have all these labels? Isn't it a lot of effort to create these labels?
  - b. Are your stickies organized? Clustered in any way? Proximity?

## FIGURE 4 - PICTURE CHECKLIST

### When To Take Pictures:

- When you first arrive in the morning
- Before and after lunch
- Retrieving your physical mail:
  - Before retrieving your mail
  - As soon as you put it on your desk
  - In the middle of your physical mail activity
  - An hour later
- Whenever you think anything interesting has happened to your desk:
  - Someone put their stuff on top of your stuff
  - Someone messed up a part of your desk
  - Someone left stuff on your desk
  - Someone forgot stuff on your desk
- Before and after throwing away items
- At the end of the day before you leave your office
- Whenever you print something
- Whenever you file away a book, document, or folder
- Whenever you create a pile, move a pile, etc.

### Example of What to Take Pictures Of:

- Desk Surfaces
- Filing Cabinets
- Trash Cans
- Bookshelves
- Input/ Output Trays



## FIGURE 6 - INTERRUPTION LOG

Date:

Time:

1. What were you in the middle of doing?  
(e.g. filling out paper work, making some related phone calls, checking e-mail, organizing files)
  
2. What was the cause/nature of the interruption?  
(e.g. an expected/unexpected visitor came into my office, an expected/unexpected telephone call, incoming fax)
  
3. What did you do at the interruption?  
(e.g. coworker wanted me to look at some documents, visitor needed advice, visitor needed some documents, visitor returning something of mine)
  
4. How long did in the interruption last for?
  
5. What did you do after the interruption?  
(e.g. continued with the task right before the interruption, moved on to a task related to the interruption, started on a new task unrelated to the previous or that of the interruption)
  
6. Did your interruption cause you to lose track or forget what you were doing before?
  
7. Did something good/helpful come from the interruption?  
(e.g. reminder to do something else, task needed to be done later, it helped with the task I was working on or will be working on later today)

FIGURE 7 — ANALYZING DIGITAL VIDEO RECORDINGS

	A	B	C	D	E	F	G	H	I	J
1	<b>Scrufler</b>									
2	4/15/2003	Tuesday								
3		<b>Filing</b>				<b>Interruptions</b>				
4		Filing Away	Create File	Access Files	Visitor Comes In	V Asks Question	V Gives Doc	V Takes Doc	V signs	
5	Totals	21	0	15	20	4	9	3	1	
6										
7	<b>8</b>									
8	8:00					1				
9	8:01									
10	8:02									
11	8:03									
12	8:04									
13	8:05									
14	8:06									
15	8:07									
16	8:08									
17	8:09									
18	8:10									
19	8:11									
20	8:12									
21	8:13									
22	8:14									
23	8:15									
24	8:16									
25	8:17									
26	8:18									
27	8:19									
28	8:20									
29	8:21									
30	8:22									
31	8:23									
32	8:24									
33	8:25									
34	8:26									
35	8:27									
36	8:28									
37	8:29									
38	8:30									







