EFFECTS OF OPEN-PLAN WORKSPACE LAYOUT
ON CREATIVITY

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ABSTRACT

The question of how the physical environment of a workspace can impact creativity has been approached from the standpoint of specific, concrete physical variables. To date, no research has categorized different layouts of open-plan offices or examined the different layouts affects on creative cognition and behavior. Consequently, the present study addressed this gap by comparing participants’ creative cognition and behavior outcomes in the same room, arranged either homogeneously (low variety, low differentiation, and rectilinear shapes) or heterogeneously (high variety, high differentiation, and organic shapes). Creativity was measured through a similarity finding task and a brainstorming task. Participants’ perceptions of the spaces, and what activities should happen in the spaces, were also recorded. A proposed mechanism of the layout influencing exploration and curiosity was explored with surveys. As was expected, participants in the heterogeneous space showed more abstract thinking than participants in the homogeneous space. Creative generation in the brainstorming task was unaffected by the difference in layout. Participants in the heterogeneous condition selected more unusual uses for the space than participants in the homogeneous room. Limitations and a future research direction are discussed.
BIOGRAPHICAL SKETCH

Lauren Bigalow grew up in Shelburne, Vermont. She graduated from Cornell University in 2012 with a Bachelor of Arts in Psychology, and minors in Film and Visual Studies. She has worked for the photography department of the Cornell Daily Sun, and as the photography editor. Before heading to graduate school at Cornell, she worked for Coffee Enterprises in Burlington, Vermont.
ACKNOWLEDGEMENTS

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INTRODUCTION

Creativity is an important aspect of many areas of the work world. Many firms seek to foster creativity and play in the workspace, equating employee creativity with business productivity and success. It thus stands to reason that creativity would be of interest to researchers in organizational behavior. Recently research has begun to address the physical environments’ affects on creative cognition. Previously research on the physical workplace environment has focused on how the workspace impacts satisfaction, health, sick leave, general work productivity, and collaboration (Danielsson & Bodin 2008; Hua 2010; Hedge 1982; van der Voordt 2003). This study looks at how creative cognition and behavior in a space is impacted by the spatial layout.

In the past few decades, the open-plan office has grown in popularity because it reduces the amount of space needed per person, and has been argued to increase collaboration and interaction between employees (Charles & Veitch 2002). With this shift away from smaller physical spaces, research has also moved from examining specific elements of the workspace to examining the social environment and the greater physical layout of the workspace (Hennessey & Amabile 2010; Hua 2010). Recently, research on the work environment has “zoomed out” to look at overarching spatial variables such as layout-level variables. There is a lack of research, however, that connects the recent interest in the effects of physical environmental variables on creativity with the recent zoom out to recognize the importance of layout-level variables. Because of this recent jump from specific spatial variables such as lighting, noise, and ceiling height, no studies to date have attempted to categorize differences in the layout of open-plan offices. This thesis proposes a new categorization of open-plan layout, in conjunction with how layout affects creativity cognition and behavior.
LITERATURE REVIEW

Creativity: How is it defined?

Originally, creativity research focused on individual personality differences and relations to creative output, however in the past few decades creativity has been studied in a wide range of contexts and environments, some of the most studied being work environments, academic environments, educational, and artistic environments (Hennessey & Amabile, 2010). It is useful to distinguish between famous and influential creativity, exhibited by notable people in artistic and scientific fields, called Big-C creativity, and the everyday brainstorming and problem solving that is called little-c creativity (Beghetto & Kaufman 2007). Little-c creativity is defined as generating an idea or a solution to a problem that is both novel and applicable (otherwise called useful or of value) and is considered situation-dependent (Amabile, 1983; Goncalo & Staw, 2006; Hennessey & Amabile 2010).

Creative cognition

When doing a creative task or solving a problem creatively, different types of thinking are necessary. These two types of thinking are convergent thinking, finding the best and most creative solution from an array of ideas, and divergent thinking, which is coming up with many unique/varied ideas for solving the creative problem (Guilford & Hoepfner, 1971; Simonton 2003; Guildford, 1967).

“Divergent thinking is widely considered to be an important antecedent to creativity because creative solutions are defined as unique or original in nature (Amabile, 1983; Goncalo & Staw, 2007). There are three components to divergent thinking: fluency, flexibility, and originality (Cheng et al. 2008; Guilford 1959). Fluency is demonstrated by the amount of
responses/solutions to a problem: the greater the solutions, the greater the fluency (Simonton, 1999). Flexibility is demonstrated by how different the ideas are to address the same problem (Leung et al. 2012). Originality is demonstrated by how novel a solution or idea is compared to past ideas (Leung et al., 2012).

There are a few important cognitive antecedents to creative behavior, and these have been broken down into a variety of constructs and processing styles. Abstract thinking has been linked to greater creative outcomes in a number of studies (Forster Friedman, Liberman 2004). Abstract thinking also called “higher construal level”, versus concrete or low construal level. Construal comes into play whenever anyone is describing or representing action: for example, one could construe “cleaning your kitchen” as a high-level “doing spring cleaning”, or as a low-level “putting dishes away” (Mehta, et al, 2012). Other mental operations that feed into creative cognition are: application of existing knowledge, analogy detection, combination generation (Welling, 2007).

Item-specific or relational thinking is another cognitive dichotomy that has been used to study abstract thinking in consumer behavior research. Relational thinking involves zooming out so that one holds multiple pieces of information in mind at once, and can see similarities amongst those pieces of information (Einstein and Hunt, 1980). In contrast, item-specific processing is concrete, low-level, and focused on context-specific characteristics (Meyers-Levy & Zhu, 2007). Relational thinking, with its free-flowing associations and high-level of construal can be categorized as a type of abstract, divergent thinking.
Measuring creativity and creative cognition

There are a number of creativity tasks that measure creative cognition. A common task for measuring convergent thinking is the Remote Associates Test, or RAT (M.T. Mednick, Mednick, & Mednick, 1964). In the RAT, participants see three words that are seemingly unrelated, for example “measure”, “worm”, and “video”, and their task is to come up with a fourth word that can relate in a phrase, the same word, or conceptually to the other three words (for this one, the answer is “tape”) (Leung et al. 2012). Another way to measure creative cognition is through insight problems, such as various riddles (Schooler et al., 1993, Friedman & Forster 2002). A measure of relational processing, developed by Meyers-Levy & Zhu (2007), presents participants with a list of things in a category (such as sports) and asks participants to name similarities among these items.

Creative generation tasks measure creative output in a variety of ways. Ward (1994) developed a structured imagination task in which participants were instructed to draw extraterrestrial creatures. In this task, creativity is scored by judges blind to the experimental conditions on how much the physical features differed from organisms found on earth (Ward, 1994). This is a measure of divergent thinking, or how a person is able to break away from previously identified constraints, also called conceptual expansion (Abraham 2014).

Other frequently used creativity generation task, done both with individual participants and groups of people, are brainstorming tasks. A common type of brainstorming task is to come up with uses for an empty retail location (Goncalo & Staw, 2007), or to generate different ways to use an object, such as a matchstick or a brick, called an alternate use task (Guilford, 1967). A common way to analyze the results of these tasks is to have raters (if applicable, experts in that particular field) rate the responses for creativity (Hennessey & Amabile, 2010). Creativity generation tasks can also be analyzed by examining the number of responses (fluency) and by
how unusual the responses are compared to other people’s responses of the same prompt (originality) and how different the responses are within the same person or group’s responses (flexibility) (Goncalo & Staw 2007).

There is obvious merit to using creative cognition tasks in addition to creative generation tasks to get a more full picture of how certain stimuli might affect not just the narrow creative output of a brainstorming task, for example, but how the thought processes behind creativity might be affected as well. It is a common mistake to completely conflate creative cognition measures with creative behavior: aspects of creative cognition such as abstract, high-construal-level thinking are antecedents to creativity, yet their presence does not always guarantee creative behavior outcomes (Runco 2008). There are also advantages to using some measures, such as the creativity generation tasks, and the similarity task, as these produce data that can be analyzed in multiple ways to support conclusions about different aspects of divergent thinking.

*Mechanisms through which the physical environment impacts cognition and behavior*

*Affordances: inviting behavior*

One of the most predominant theories in environmental and perceptual psychology is James Gibson’s theory of affordances. Gibson viewed affordances as “action possibilities” that various objects or environments possessed, that were defined relative to the person or animal acting upon it (Gibson, 1986). Withagen et al. (2011) reinterpreted Gibson’s ideas of affordances and discuss instances where affordances are not just action potentials but have a more subtle and nuanced effect. Pulling from phenomenology and industrial design/architecture, Withagen et al. (2011) argues that affordances invite certain behaviors: “designing a building is not merely designing a layout of action possibilities or creating an aesthetic experience.
Architects can also contrive places that invite certain behaviors” (p. 254). Taking the Gestalt psychologists view of affordances, Dreyfus & Kelley (2007) use the term “solicitations to act” to define affordances.

It is a common belief that the physical environment of the workspace, while affording definite actions such as computer work, can also “invite” certain behaviors such as play, creativity, mingling, and spontaneous collaboration. Indeed many designers of the modern workspace operate under the assumption that if they make a space that has “creativity potential” (Vithayathawornwong et al. 2003) that this will invite or solicit creative behavior on the part of employees within the space.

Currently there have been very few studies on how the physical environment in a workplace might prompt such a change in thinking style and/or behavior. Meyers-Levy & Zhu (2007) proved that physical environment, specifically ceiling height, influences processing style. Maeng & Tanner (2012) have shown that crowded environments impact processing style through the mechanism of triggering an avoidance motivation. Lighting conditions also influence creative cognition (Steidle & Werth 2013).

Situational norms

The concept of situational norms in social psychology runs parallel with the concept of affordances as invitations or solicitations (Withagen et al. 2011, Drefus & Kelley 2007). Physical environments, such as libraries, activate behavior norms such as being quiet or talking quietly (Aarts & Dijksterhuis 2003). Even just a quick 30-second exposure to a picture of a library, a place with the established behavior protocol of being quiet, causes behavior change towards the normative, quiet behavior. This study prompts the question of what aspects of the
library physical environment elicited compliance with the social norm of being quiet. It is possible that low level architectural or interior design features such as rows of desks may trigger these concepts and social norms.

Physical environments that are “meaning-laden” environments have effects on behavior. Rutchick (2010) found that when voting in places such as churches, voting behavior and altruistic behavior is influenced. The situational norm was only influential to people, Christians in this case, to whom the meaning-laden environment was important. Christians were more likely to vote for conservative candidates or for support amendments that were in line with Christian values (Rutchick, 2010). Office spaces are similarly stereotyped spaces that hold a lot of meaning. In this vein, many studies have examined various perceptions of different spatial features of offices (Vithayathawornwong et al. 2003, Ceylan et al. 2008).

**Priming and material priming effects**

The “office” environment of the 21st century has many unique characteristics that distinguish it from other spaces. For example, cubicles aren’t usually present in any other space type. Materials that people use in the office are so specific that there are stores catering just to the need for “office supplies”. Material objects and physical environments can send visual messages and can prime concepts or different styles of cognitive processing (Zhu & Argo, 2013). Consumer behavior research shows that the surrounding physical environment can influence thought and behavior.

Objects common in the physical environment of an office space can prime concepts of competition. Kay et al. (2003) explored the effects of material priming on situational construal and behavior choice. They found that by showing participants images or being in the presence of
physical objects related to a business setting (briefcase, boardroom table, etc) primes concepts of competition, and elicits more competitive behavior.

The contemporary workspace has seen a trend towards blending with other types of spaces. The “Google office”, for example, incorporates elements of play and relaxation into work areas (Johnston 2014). Kay et al. (2003) produced the effects of business material priming only seen when the participant was operating in an ambiguous situation (the labeling of the activity was more ambiguous). In their discussion, they pose this question: “will employees aim for more creativity in their work if there happens to be an artists’ easel placed as decoration in their work environment rather than a plastic tree?”. Their finding about ambiguous situations/environments fits well with the contemporary open office which tends to ambiguity for purposes and activities. This thesis addresses a similar question: what cues are being sent by the spatial properties of contemporary offices, and how might these cues affect creativity?

Trends in office design over the years have incorporated a variety of furniture, colors, and shapes into the office setting. The “office landscape” movement in the 1970’s (Brookes 1972) as well as recent trends in office design show an inclination of innovative firms to use a variety of shapes, colors, and furniture types in their workspaces. The psychological priming literature shows that preference for uniqueness and variety are affected by simple primes such as lines of geometrical shapes and presence in a confined space (Maimaran & Wheeler 2008, Levav & Zhu 2009).

Exposure to “variety arrays” such as “OVOXVOX” prompts people to have a preference for variety, and exposure to “uniqueness arrays” such as “XXXXOX”, prompts preference for unique items (Maimaran & Wheeler 2008). These arrays and their effects on preference for uniqueness/variety are powerful as they are strings of shapes without prior associations and they
had effects on actual behavior. The exposure to these shapes in Maimaran & Wheeler (2008) was similarly fleeting to how people experience elements of their environment: often people are aware that there is a variety of furniture in a certain room, but they do not actively think about the furniture variety.

Small spaces affect peoples’ preference for variety and uniqueness. People in confined spaces make choices that maximize variety and uniqueness (Levav & Zhu 2009). Levav & Zhu (2009) showed that confinement impinged on personal freedom, which caused people to be attracted to novelty or variety in their choices as a way to regain a sense of freedom. There are many ways a person may feel confined by his/her physical environment in an office setting. A cubicle or the layout of furniture could both contribute to senses of confinement.

Primes from shapes in the physical environment influence values and self-concepts which in turn influence behavior. Mere presence with physical variables such as the shape of a seating arrangement or confined space shifts cognition and behavior. Environmental cues coming from seating shape/arrangement influence responses to persuasive material (Zhu & Argo 2013). Circular seating configurations prime the need to belong, which results in people agreeing with a conventional, majority opinion (Zhu & Argo 2013). Angular seating configurations prime the need to be unique, which results in people agreeing with a unique, minority opinion (Zhu & Argo 2013). The difference in peoples’ mental concepts and behaviors when sitting in circular or angular tables applies directly to the office environment. For many decades, office design elements were primarily angular: cubicles are usually square or rectangular, board room tables are usually long and rectangular. Recently, with the advent of the “open office”, office design has incorporated shapes that deviate from the angular.
Perceived “creativity potential” of a space

The above three psychological mechanisms for the impact of physical environment on creativity can all combine to create a space that is judged to have “creativity potential”. Most work on the creative environment has focused on the social or organizational environments (Amabile & Gryskiewicz 1988, Hennessey & Amabile 2010). McCoy & Evans (2002) extrapolated from these organizational characteristics (such as freedom, challenge, supervisor, recognition, cooperation) associated with creativity, and presented seven dimensions of the physical environment relevant to creativity: nature, challenge, freedom, support, coherence, threat, and status quo. People rated images of spaces for these dimensions, and then also sorted the spaces based on preference for using the space for creative activities. McCoy & Evans (2002) then asked a team of design professionals to come up with space terminologies for the physical settings rated previously. These were: spatial form (size/shape of room), light, internal organization of objects, characteristics of bounding surfaces, color, texture, and transparency. Spaces that were judged as high in creativity potential were visually interesting and complex (both in the shape of the space and the furniture and textures).

Studies examined how spatial elements of offices impact perceived employee creativity. The phenomenon of a space being interpreted as having “creativity potential” has begun to be investigated through examining existing workspaces. Dul & Ceylan (2011) compiled 9 different social-organizational work environment elements and 12 physical work environment elements that have been addressed in previous literature. These twelve physical work environment factors were: furniture, indoor plants/flowers, calming colors, inspiring colors, privacy, window view of nature, any window view, quantity of light, daylight, indoor climate, sound, and smell. They examined how self-reported employee creativity in a business setting is related to these elements.
However this study did not differentiate between the 12 different physical environment elements, and just reported that higher creative performance was correlated with higher perceived support for creativity from the physical environment. In addition, this study lacked other literature to support these 12 physical work environment elements.

Instead of finding an interaction between the social-organizational environment and physical environment elements, as proposed by Vithayathawornwong et al (2003), they found a direct connection between the physical environment and creative self-report. Vithayathawornwong et al. (2003) examined four different organizations and collected quantitative and qualitative information on the physical and organizational environments, as well as self-report creativity. They identified two social work environment factors – freedom and dynamism – that are supported by elements of the physical environment. Dynamism was defined as including “interpersonal interaction, communication, and information and idea exchange”, and this was found to be most correlated with office layout and spatial arrangement. However, Vithayathawornwong et al. (2003) do not go into the specific elements of the office layout/spatial arrangement besides open versus closed floor plan. Freedom was defined as including “autonomy, sense of control (over one’s work), and freedom from control”. Freedom was found to be most correlated with provision of “stretch-out facilities” and “break areas”, and second most with office layout/spatial arrangement. There is much to be uncovered here if the concept of the open office was more specifically defined. Many open plan offices have a mixture of spaces that are semi-differentiated and a mixture of furniture.

Ceylan et al. (2008) examined manager’s perceptions of creativity potential of an office by breaking the office environment down into various spatial elements such as the presence of plants, natural/manufactured materials, color, light, complexity, and furniture. They found that
offices with low complexity, cool colors, plants, and that are brightly lit are associated with high creativity potential. Managers judged these spatial elements as fostering novel thinking and concentrating, and related these spaces to freedom of thought. However, the “offices” that they had managers rate were presented as large individual offices that differed in many aspects that may have been considered in the “complexity” scale. The only prompt for complexity was “please evaluate the amount of structural elements in each office photograph” and participants were given a seven point scale from 1 (extremely low) to 7 (extremely high). This study did not address offices on the layout level, and did not include any measures of self-reported creative output or measured creative output.

These studies represent a good spread of methods examining perception of office environments and the creativity potential of these environments. These studies are beneficial in that they attempt to deconstruct the office physical environment into more concrete elements and compare them with self-reported creativity or with perceived creative potential. However none of these studies address actual creative output or make solid connections between specific elements of the physical environment and specific creativity outcomes.

*Physical space as an independent variable in creativity research: Spatial variables that impact creative cognition/construal outcomes*

The field of environmental psychology has spent the last handful of decades studying the relationship between the physical environment and human health, wellbeing, cognition, and behavior. Much research is focused on the workplace: employees spend many hours a week in these locations and it is advantageous for both the individual employee and the company to support employee health, happiness, and behaviors through the design of the physical office.
setting. However, in the field of environmental psychology, there has not been a comprehensive examination of how different spatial variables affect creativity.

The consumer behavior research has delved into how certain aspects of the physical environment affect creative cognition. Ambient noise, ceiling height, and physical crowding in a space can all impact creative cognition (Mehta et al 2012, Meyers-Levy & Zhu 2007, Maeng & Tanner 2012). Exposure to a moderate level of ambient noise causes abstract cognition, and in turn augments creativity. Mehta et al. (2012) investigated the mechanism behind this effect, and showed that the moderate level of noise induced processing disfluency, in other words, that the medium level of noise interrupted processing speed and ease. High levels of noise also increased abstract construal level, however instead of just interrupting information processing, the loud noise reduced the amount of information processing.

Ceiling height can have an impact on relational or item-specific processing. The higher the ceiling, the more freedom-related concepts were primed in participants, and the more relational and abstract their thought process was (Meyers-Levy & Zhu, 2007). Meyers-Levy & Zhu (2007) used a small office-sized room to conduct this experiment, and made the ceiling height salient to participants through hanging paper lanterns from the ceiling. Social crowding can also influence construal level.

Through a prime of a picture of a crowded space, or through actual physical crowding, people adopt a more concrete level of construal (Maeng & Tanner, 2012). Crowding influenced avoidance motivation, which in turn influenced construal level. These studies on creative cognition and physical space examined quite varied mechanisms for how the space had influence: noise was through disrupting processing slightly, ceiling height primed freedom
related cognitive concepts, and crowding had an embodied cognition effect of inducing avoidance motivation.

**Spatial variables that impact creative behavior outcomes**

Studies have examined how specific elements of the physical environment can impact creative behavior outcomes in a lab setting, as opposed to self-report or manager-report research in workspaces. Steidle & Werth (2013) demonstrated through a number of studies that the experience of darkness (either primed or actual) increases creativity and is mediated by increasing perceived freedom from constraints. They demonstrated these effects with a number of measures of creativity. They also showed that exposure to bright light, as opposed to dim light, increased performance on an analytical thinking task. They argue that darkness “changes a room’s visual message” and therefore instigates the changes in perceived freedom from constraints and in turn augments creativity. This link between a room’s visual message and perceived freedom from constraints can be expanded upon. A room’s visual message may send freedom signals in many ways. As is common in the “google-ified” office, spaces are ambiguous and can be there for work, or play, or both (Johnston 2014). It is highly possible that features of the physical environment such as colorful features, interesting and unconventional furniture, and presence of play objects like ping pong tables may also send a visual message that increases perceived freedom from constraints. It is also possible to see a link between offices that are extremely conventional – with such features as rows of desks or endless cubicles – as impinging on freedom from constraint.

Vohs et al. (2013) pursued the question of whether environmental order/disorder impacts preferences for moral and conventional choices, and whether order/disorder impacts creative
output. In their first experiment, they found that participants’ presence in an orderly (but sparse) large office encouraged more healthy choices and higher donations to charity in comparison to participants who completed surveys in a similar, but disorderly room. In their second experiment, they found that participants in a disorderly room generated more creative ideas and showed higher overall creativity than participants in an orderly room. The third experiment tested whether being in an orderly vs disorderly room would influence participants’ preference for novelty or conventionality. Vohs et al. (2013) found that room orderliness and novelty interacted such that participants in a disorderly environment preferred novelty, and participants in an orderly environment preferred conventionality. In conclusion they surmise “disorderly environments seem to inspire breaking free of tradition, which can produce fresh insights”. In all of these experiments, order/disorder was manipulated with small objects such as papers, files, and desk items, and in rooms that were small-to-medium office and conference rooms. Vohs et al. (2013) does not explore the effects of order versus disorder in a larger environment. It is highly possible that the layout of an open space can be interpreted as orderly or disorderly, which in turn might prime similar concepts of novelty and influence creative output.

Leung et al. (2012) pursued the notion that various metaphors relating to creativity might influence creative performance. Of particular interest to the problem of how space impacts creativity was their investigation of the “thinking outside the box” metaphor. To do so, they conducted several manipulations. The first manipulation involved participants completing a remote associates test (RAT) while seated inside a PVC-pipe box, outside the box, or with no box present. Leung et al. (2012) found that accuracy in RAT responses was highest in the “outside the box” condition. They also investigated whether physically embodying a box would have similar effects. Participants who walked freely generated more original captions for
ambiguous pictures and came up with more original ideas for small Lego structures, versus participants who walked along a duct-tape box laid on the floor or participants who did not walk. Leung et al. (2012) went on to show that controlling an avatar walking in a box (or sitting or walking freely) had similar effects on creative output. Spaces that involve a lot of square or rectangular elements, such as open plan offices with a lot of cubicles, may also relate to such metaphors.

The importance of layout-level variables: Layout impacts perception and behavior

Open offices are a major type of office (Danielsson & Bodin 2008). The spatial variables that have been studied in how they impact creativity are specific low-level features of the physical environment. It is necessary to “zoom out” and examine layout-level variables as well. Evidence that layout can impact perception and behavior can be found scattered throughout the psychology literature in various disparate corners. Even research on the enriched environment of rats is essentially research on the layout of the cages (and the presence of different “furniture”) (Rosenzweig et al. 1972). Developmental psychologists have studied how environments affect childrens’ behavior. Spatial differentiation had affects on a child’s degree of engagement, cooperative behavior, and amount of exploratory behavior: the more spatial differentiation was present, the better these behavior outcomes were (Moore, 1986). Spatial differentiation in Moore (1986) was categorized into three conditions: well-defined behavior settings, partial-defined behavior settings, and poorly defined behavior settings. Abbas & Othman (2010) replicated the findings of Moore (1986) and other studies, studying Malaysian daycares and children. Differences in ceiling height and wall color also positively impacted child behavior (Read et al. 1999).
Studies with adults also point to affects of layout or total-room variables. In the hospital setting, it was found that a larger consultation room positively influenced patient comfort and self-disclosure. In addition, perceived spaciousness impacted the perception of comfort (Okken et al., 2012). Self-disclosure and positive affect increased in intimate conversations that occurred in a larger room (Okken et al., 2012).

Open-plan office space typologies to date

To date, studies on how the physical environment affect creative cognition and creativity have examined concrete features of the ambient environment (ceiling height, noise, lighting), or social-physical environment factors such as crowding. The creativity and physical space literature, being based in a variety of fields such as psychology and consumer behavior, has thus far neglected to examine how layout features may influence cognition and behavior.

So far the creativity literature has approached space quite concretely. It is necessary to adopt a more broad (abstract, if you will) perspective: space is not just comprised of concrete characteristics, there are also higher-level layout spatial variables. To adopt this approach, it is useful to define the different types of layouts found in open plan offices. Hua (2010 & 2011) made a similar leap in her work looking at what features of the physical environment impact collaboration.

Up until Hua (2010 & 2011), literature that examines effects of office environments on varieties of outcome variables, such as health, well-being, or job satisfaction (Danielsson & Bodin 2008) have used both general categories of offices and very specific office characteristics such as noise and light levels. There are seven office types that are commonly defined (Ahlin & Westlander 1991; Duffy 1999; Danielsson & Bodin 2009).
Table 1: Typically defined office types

<table>
<thead>
<tr>
<th>Type of office</th>
<th>Office description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell offices</td>
<td>1 person per room</td>
</tr>
<tr>
<td>Shared-room offices</td>
<td>2-3 people per room</td>
</tr>
<tr>
<td>Small open-plan office</td>
<td>4-9 people per room</td>
</tr>
<tr>
<td>Medium open-plan office</td>
<td>10-24 people per room</td>
</tr>
<tr>
<td>Large open-plan office</td>
<td>&gt; 24 people per room</td>
</tr>
<tr>
<td>Flex-office</td>
<td>Open-plan without personalized workstations</td>
</tr>
<tr>
<td>Combi-office</td>
<td>No strict spatial definition</td>
</tr>
</tbody>
</table>

Hua et al. (2010) highlighted how previous research on behavior in the workplace environment focused too narrowly on individual workstation variables. Calling for an exploration of layout and workplace-scale variables, the study proposed six new layout-scale variables: three measured the distance from individual workstation to shared areas (meeting spaces, copy/print, and kitchen spaces), two measured the percent of floor space dedicated to shared spaces, and one measured openness of the space.

A few scattered studies have begun down the road of categorizing elements of open-plan offices. The variable of openness introduced in Hua et al. (2010) starts to address the need to categorize types of open-plan office. Brookes (1972), when the office landscape was becoming popular, identified various features of the new office landscape as it differed from the previous office landscape: rectilinear vs. organic shapes, and walled corridors vs. partial partitions and no formal walled corridors. McCoy & Evans (2002) also approached layout variables with their examination of spatial form (shape of the rooms), and the “internal organization of objects”,

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although this was defined not purely spatially but as a function of interaction as sociofugal or sociopetal arrangements.

No studies to date have categorized open-plan offices in terms of layout variables. Layout, in an open-plan office, encompasses the arrangement of furniture in an open room, and the presence/arrangement of partitions. I propose a categorization of layout on a spectrum of homogeneous layout and heterogeneous layout. In line with the office landscape characteristics, studies on how layout affects behavior, and previous office typologies, I synthesized these sources into how spatial layout differs on three factors: differentiation, variability, and shapes or arrangements. Differentiation refers to the presence of partitions and half walls that break up the space. Variability refers to how much the layout changes/differs in the space from one area of the space to another. The shapes of furniture arrangements can be either rectilinear or more organic, with shapes of furniture and shapes of furniture arrangements that are more circular or angled. Homogenous space has low differentiation and is rectilinear. Heterogeneous space has high differentiation, high variability, and organic arrangements of furniture.

Table 2: Homogeneous versus heterogeneous space characteristics

<table>
<thead>
<tr>
<th>Homogeneous space</th>
<th>Heterogeneous space</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low differentiation</td>
<td>High differentiation</td>
</tr>
<tr>
<td>Low variability</td>
<td>High variability</td>
</tr>
<tr>
<td>Rectilinear shapes</td>
<td>Organic shapes</td>
</tr>
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</table>
Hypotheses and Research Questions

This thesis examines the following research question: how might the layout of an open workspace influence creative cognition and creative output? Specifically, how might a homogeneous layout differ in effect on creativity from a heterogeneous layout?

My hypotheses are:

• H1: An open-plan workspace that is heterogeneous will prime people to think more abstractly.

• H2: An open-plan workspace that is heterogeneous will augment creative performance on a brainstorming task.

• H3: The heterogeneous layout will augment exploration and novelty-seeking self-identification, and this would mediate the relationship between the physical layout and creative outcomes.

• H4: Heterogeneous space would prompt people to select more unconventional uses for the space.
METHODOLOGY

Research design and set-up

In order to test the hypotheses and answer the research questions discussed previously, a lab-based psychology study was conducted. Two conditions were tested: a condition in which the furniture arrangement was homogeneous and one in which the furniture arrangement was heterogeneous.

Physical room set up

I chose a room that would be able to represent the extremes of each of these three dimensions. In Martha van Rensellear Hall, active learning classrooms were recently built to include portable white boards and furniture that was on wheels. The tables were trapezoidal, and thus were easy to rearrange into rectilinear or nonrectilinear arrangements. The classroom used for these studies was sometimes reserved for classes but was open all day as a study space as well. The room was a typical classroom size, measuring 30 x 60 ft, and 900 sq ft. In Figure 1, below, the blue table and chair were where participants were seated in each condition. Figure 2 shows pictures of the homogeneous layout, and Figure 3 shows pictures of the heterogeneous layout.
Figure 1: The floor plan view of the layout of the homogeneous condition and the heterogeneous condition. The blue indicates where the participants sat in each condition.

The homogeneous setting had furniture arranged in rows of four desks facing four desks. The moveable white boards were pushed to the walls of the room, and evenly spaced along the
walls. Chairs were paired with the desks. The heterogeneous setting had a variety of furniture groupings, which were in a variety of shapes. The moveable whiteboards in the room were scattered throughout the room and placed next to the various furniture groupings.

All of the furniture in both conditions was the same. There were 24 tables and 24 chairs in each condition. In both conditions, a moveable whiteboard was placed in front of the classroom podium present to block it from the sight line of the participant. None of the whiteboards had any writing or drawings on them during the experiment. The study was conducted on paper, and the papers were placed at a certain place setting. Participants in each condition faced the same direction in the room.

In both conditions, the lights were fully on and the blinds were closed fully on both of the windows. The lights were fluorescent lights, on full brightness. The noise level in the room was on average 40 decibels. The room was off of a dead-end hallway, and at no time did noise in the hallway interrupt any participants during the experiment.

Figure 2: Pictures of the homogeneous layout
Recruiting process and condition placement

Participants were recruited with multiple methods. Flyers were hung around university buildings, offering extra credit in participating classes or $5 as a reward for participation. The flyer heading was “Curious about creativity?” and did not mention the physical setting or the manipulation of the layout as the independent variable of interest. Participants were also recruited by advertising (using the same flyer) as the first slide of a large introductory course on environmental psychology. I then followed up with the participants via email and let them choose a day/time that worked for their schedule.

Participants were placed in one condition or the other based on the day they signed up for the study. It was impractical to reorganize the room’s layout for each new participant, so the arrangement of the room was rotated through by day. Data was collected over the course of 9 days. There was distinguishing events that occurred over these days and no instance where a particular person would’ve selected a particular condition/day over another.
Experiment process

Only one participant was run at a time, and the only other person in the room was the principal investigator each time, seated at a distance of 15 feet away. Each participant completed a brainstorming task and a similarity task. The order of these tasks was counterbalanced between subjects. The brainstorming task was modeled after Goncalo & Staw (2006). This was adapted to be an individual task, and each participant was given 5 minutes. The brainstorming prompt was as follows: “Consider the following scenario: After years of mismanagement and poor quality food, a university restaurant has finally gone bankrupt and is being shut down. The school administration is trying to decide what new business should go into that space. You will now have 5 minutes to generate as many ideas as possible on what new business should go into that space.”

The similarity task was modeled after Meyers-Levy & Zhu (2007). Participants were given a list of 12 sports, such as soccer, hockey, tennis, and were asked to “Identify as many dimensions that some or all items in this list share”. Following Meyers-Levy & Zhu (2007), this task was not timed.

After completing the brainstorming and similarity tasks, participants then answered a survey including items from the Big Five Personality questionnaire – specifically about openness – and from the curiosity and exploration inventory (CEI-II) (Kashdan et al. 2009). The survey also included items asking about their current feeling, motivation for the tasks, and enjoyment of the tasks. In addition, there were four survey items which addressed preference for the room. All survey items were on a 5-point Likert scale. After this survey, participants were given a list of 29 possible uses for the room and asked to select up to 10 possible uses. A variety of uses were presented, from very conventional (listening to a lecture) to very unconventional uses.
(having a picnic). Participants were also given questions pertaining to how much they enjoyed the space and how much the space was similar or different to where they would usually do work. Demographic information such as age, gender, and occupation were collected at the end of the study session. The majority of participants completed these tasks in about 20 minutes. Participants were debriefed as to the room layout manipulation after the completion of the surveys, and if applicable were given their $5 after participating.

**Dependent variables**

**Similarity task: Similarity generation to measure relational versus item-specific processing**

Relational processing is related to the amount of connections and links a person can produce (Einstein & Hunt, 1980). Therefore in this task, the number of similarities/similar qualities that participants generated were counted.

**Similarity task: Abstraction level of similarity responses**

It was also possible to code the responses to the similarity task based on how abstract or concrete the responses were. The abstraction level of responses was coded following the process laid out in Meyers-Levy & Zhu (2007), in which they adapted the linguistic category model (LCM) described in Semin and Fiedler (1988, 1991). Three levels of abstraction were used here: the 1st, lowest level, included similarities that were concrete and easily measurable. These are called objectively interpreted dimensions (OID). An OID similarity for the sport list would be the size of the ball, for example. The second abstraction level, subjectively interpreted dimensions (SID), are similarities that are less concrete and more reliant on interpretation and judgment, such as “sports that require a intense activity”. The third abstraction level used by Meyers-Levy
& Zhu (2007) was the psychological state dimensions (PSD). These abstractions were
categorized by relating the list items to oneself or one’s psychological state, such as “sports
that I have played”, or “sports that I think are interesting”. I encountered a fourth level of
abstraction: participants sometimes referred to the list of items not as sports, but as words, and
came up with similarities based on the names of the sports. The abstraction score was calculated
by multiplying each level 1 abstraction by 1, each level 2 abstraction by 2, each level 3 by 3, and
the new level by 4.

Brainstorming task: Idea generation to measure fluency

The production of a lot of ideas from one problem or brainstorming session has been
associated with creative process and solutions (Campbell 1969; Simonton, 1999). Idea
generation in this task was measured by simply counting the number of ideas each participant
came up with in the five minutes they were given to do the brainstorming task.

Brainstorming task: Convergent vs. divergent thinking to measure flexibility

Previous studies have developed ratings for the flexibility of ideas generated (Guilford,
1956, Mayer, 1992) as a way to measure convergent/divergent thinking. Flexibility in this sense
is the ability of a person/group to come up with ideas that span different categories. Goncalo &
Staw (2007) developed a method for assessing the flexibility of ideas that I followed in this
study. Each idea was given a number for how many times participants as a whole had come up
with that idea. For example, 6 participants came up with the ideas of a laundromat, so each
participant who suggested a laundromat were given a score of 6 towards their total score. Each
participants’ flexibility score was an average of the points generated from each idea. The lower the score, the more flexible and divergent the ideas were.

*Brainstorming task: Subjective rating of creativity to measure originality*

Once again following the procedure used in Goncalo & Staw (2007), three coders who were blind to the experimental conditions coded each idea on a 5-point Likert scale for creativity (1 = very uncreative and common, 5 = very creative, novel, and original). The coders were instructed to rate the ideas purely based on novelty.
RESULTS

In total, there were 60 participants. All participants were affiliated with Cornell University, either as undergraduate students, graduate students, or visiting scholars. 30 participants were completed the tasks and surveys in the homogeneous room, and 30 participants completed the tasks and surveys in the heterogeneously arranged room. There were 16 men and 14 women in each condition. 57 participants were in the 18-29 age group, 2 participants in their 30’s, and one participant was in her 40’s. I performed a linear model, including condition, gender, order of tasks, and any interactions between gender and condition, and condition and order. I started with a full model with (all the variables) and performed backwards selection to remove non-significant terms until further removal would make the model worse.

Descriptive statistics

Table 3: The mean, minimum, median, max, and standard deviation of the outcome measures for all of the participants.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Min</th>
<th>Median</th>
<th>Max</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Similarity task: Number of similarities</td>
<td>10.5</td>
<td>2</td>
<td>9</td>
<td>27</td>
<td>5.8</td>
</tr>
<tr>
<td>Similarity task: Number of level 2,3,4 abstractions</td>
<td>3.9</td>
<td>0</td>
<td>3</td>
<td>19</td>
<td>3.9</td>
</tr>
<tr>
<td>Brainstorming task: Number of ideas generated</td>
<td>14.3</td>
<td>2</td>
<td>11.5</td>
<td>55</td>
<td>10.5</td>
</tr>
<tr>
<td>Brainstorming task: convergent/divergent thinking score (lower score = more divergent)</td>
<td>100.9</td>
<td>50.7</td>
<td>97.9</td>
<td>190.8</td>
<td>31.8</td>
</tr>
<tr>
<td>Brainstorming task: subjective creativity ratings (rated on Likert 1-5 scale)</td>
<td>2.6</td>
<td>1.7</td>
<td>2.6</td>
<td>3.9</td>
<td>0.5</td>
</tr>
<tr>
<td>Space uses: unusual space score (lower score = more unusual space uses selected)</td>
<td>23.57</td>
<td>15.43</td>
<td>23.71</td>
<td>31.4</td>
<td>3.3</td>
</tr>
</tbody>
</table>
Similarity task: Relational processing/Abstract thinking

Each participant’s number of similarities that they generated was counted. Dichotomies of similarities, such as “sports that are played in teams” and “sports not played in teams” were counted as two separate similarities. The linear model revealed a significant main effect of condition: the number of similarities identified was significantly less in the homogeneous condition (mean 9.03 similarities) to the heterogeneous condition (mean 12 similarities), F(1,56) = 4.29, p < .05.

Figure 4: The number of similarities generated in the similarity task in the heterogeneous layout and the homogeneous layout.
Abstraction level

Each participants’ number of level 2, 3 and 4 abstractions that they generated was counted. For this measure, I fitted a general linear model with a Poisson distribution, and a log link because the count distribution was a classic Poisson distribution. The linear model revealed no significant main effect of condition. There was a marginally significant interaction of condition by gender: men in the homogeneous room produced significantly less level 2,3 or 4 abstractions (mean 1.75) than men in the heterogeneous room (mean 5.44), $\chi^2_1 = 3.76$, $p = 0.052$. I conducted planned contrasts that revealed a significant difference between men in the homogeneous and heterogeneous conditions $F(1,43)=7.96$, $p=0.007$.

Figure 5: The average number of level 2,3 and 4 abstractions in the heterogeneous condition versus homogeneous condition, plotted by the gender of the participant
Brainstorming task: Fluency as shown by idea generation

Each respondents’ number of ideas that they generated was counted. The linear model revealed no significant main effects. Participants in the homogeneous room came up with a mean of 13.67 ideas, and participants in the heterogeneous condition came up with a mean of 15 ideas.

Brainstorming task: Flexibility as shown by convergent/divergent thinking

Each respondents’ flexibility score was calculated. There were no significant main effects: participants in the homogeneous room had a similar flexibility score (mean 100.62) to participants in the heterogeneous room (mean 101.21).

Brainstorming task: Originality as shown by subjective creativity ratings

Each respondents’ set of ideas was scored by two coders blind to the condition of the respondent. There was a main effect of task enjoyment on creativity score: the more enjoyment for the tasks a person self-reported on a 5 point Likert scale, the higher the creativity score, F(1, 54)=4.62, p<0.05. For example, participants with a score of 2 on the enjoyment scale (1 being not enjoyable, 5 being very enjoyable), had a mean creativity score of 2.75, and participants with a score of 5 on the enjoyment scale had a mean creativity score of 2.8.

Space perception: Affordances judgment

Each respondents’ judgment of what activities should occur in the space an unusual uses score was calculated for each respondent. The unusual score is calculated such that a lower number indicates choices that were more unusual, and a higher score indicates choices that were more common. There was a significant main effect of condition on unusual uses score:
participants in the homogeneous condition selected more unusual uses for the room (mean unusual score 22.97) than participants in the heterogeneous condition (mean 24.18). There was a significant main effect of the order of activities on the unusual uses score: participants who started with the brainstorming task selected more common uses for the room (mean 23.85) than participants who started with the similarity task (mean 23.27). There was a significant main effect of the curiosity and exploration inventory self-report on unusual uses (Figure 4): the higher the participants’ preference for exploration and novelty, the more unusual uses the participant selected for the room.

Figure 6:
Scatterplot with best linear fit line showing the relationship between self-report on the Curiosity and Exploration Inventory and a person choosing unusual uses for the space
There was a significant interaction of condition by order on the unusual score, F(1,43)=4.41, p < 0.05. I conducted a planned contrast that revealed a marginally significant difference in the heterogeneous condition F(1,43)=3.22, p=0.079: participants in the heterogeneous condition who started with brainstorming selected more common uses for the room (mean 25.37) versus participants who started with the similarity task (mean 23.08), see Figure 5.

Figure 7: The average unusual scores in the heterogeneous condition versus homogeneous condition, plotted by the order of the experimental tasks (brainstorming task first = blue circle, and the similarity task (cat) = pink triangle).
In summary, the reduced models with significant predictors are reported in Table 4.

Table 4: Reduced models

<table>
<thead>
<tr>
<th>Condition</th>
<th>Order</th>
<th>Gender</th>
<th>Big5:Openness</th>
<th>CEI</th>
<th>Motivation</th>
<th>Feel good</th>
<th>Condition: order</th>
<th>Condition: gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of similarities</td>
<td>0.043*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level of 2,3 and 4 abstractions</td>
<td>0.57</td>
<td>0.27</td>
<td>0.50</td>
<td></td>
<td></td>
<td>0.0285*</td>
<td></td>
<td>0.052 (*)</td>
</tr>
<tr>
<td>Space uses: unusual score</td>
<td>0.0206*</td>
<td>0.045</td>
<td></td>
<td></td>
<td>0.047*</td>
<td>0.328</td>
<td></td>
<td>0.042*</td>
</tr>
</tbody>
</table>

* = significant to the p<0.05 level
(*) = marginally significant, p<0.1
DISCUSSION

This research contributes to the fields of environmental psychology and creativity research by demonstrating a difference in creative cognition between two open workspaces that differed based on layout. This study showed that the layout of an open workspace influences the type of processing people use. More specifically it shows that a layout that is heterogeneous, and possesses characteristics of differentiation, variability, and organic shapes, can positively influence the creative cognition of people doing work in that space. The results of the similarity task supports the hypothesis that the layout of an open workspace influences creative cognition: participants in the heterogeneous room displayed more relational processing and abstract thought, and came up with more similarities for a list of items than participants in a homogeneously arranged workspace.

Performance on the similarity task, the number of similarities generated, is obviously confounded with the amount of time a participant chose to spend on the task. Unlike the brainstorming task, the similarity task was not timed, and participants could choose when they would stop the task to move onto the next activity. I did not time the participants for this task, however, every study participant finished all of the study’s tasks between 15 minutes and 25 minutes in duration. However, there still could have been a lot of variation in the amount of time that a person spent on this task. Even if time is an explanation for this finding, it still is of interest: the heterogeneous room layout still influenced people in a positive direction, and they chose to spend more time on this task and/or thought more abstractly about it. The field of creativity research has focused a lot on whether people who are creative are intrinsically motivated or extrinsically motivated (Amabile 1996). It is possible in this study that motivation was driving participants’ efforts to spend more time on the similarity task. Only one item on the
survey addressed motivation to do the tasks, and did not distinguish between external or internal motivation. A whole future area of research would be how a space could promote intrinsic motivation, which has been shown to be beneficial to creativity (Amabile 1996).

Unexpectedly, when these similarities were coded for abstraction, there was a marginally significant difference interaction of gender by condition on abstraction score. It appears that men’s production of abstract similarities were more affected by the room layout than women’s abstraction level. This finding is interesting, because there have been no other similar findings in the creativity research on gender differences in abstraction level relating to the physical environment. In this particular task, I asked participants to find similarities about a list of sports. While it is a generalization, yet it is possible (especially in American culture) that the male participants knew more about the specific features of the sports than the female participants, and therefore could report more specific similarities, such as rule, court, and equipment similarities.

A gender difference, especially as an interaction between gender and condition, was not expected. Most creativity research has shown no significant gender differences in creative task performance (Baer & Kaufman, 2008). Creativity research using behavioral and fMRI measures showed gender differences in brain area activation but not in creative behavior outcomes (Abraham et al. 2014). The interaction found in this study between physical layout condition and gender is worth looking at in future studies on the physical environment and creativity.

This study did not find any impact of room layout on creative performance in a brainstorming task. This runs in line with Runco (2008)’s arguments that creative cognition are antecedents to creativity but do not necessarily guarantee a creative behavior output. However, this is the first study to address the physical environment in terms of layout and how this might impact creativity, and one of the only physical environment studies to use multiple creative
cognition and generation tasks. This difference in outcomes suggests the need for more comprehensive creative tasks used in future physical environment research.

The time limit imposed on the brainstorming task could have limited the affects of the condition manipulation: this particular brainstorming task is usually conducted for 10 minutes (Goncalo & Staw 2007), and usually conducted in groups. It is possible that the five minute time limit restricted the amount of divergent thinking because it was only during this time that people would have exhausted more convergent ideas. It is also possible that by imposing an obvious time constraint, participants felt pressured or primed to spend less energy or motivation on this task. A way to parse this would be to ask the survey items about feeling, motivation, and enjoyment after each individual task, instead of in a block at the end of the task.

Group creativity is commonly measured with this particular restaurant task (in Goncalo’s papers), however this study only looked at individual creative behavior. It is possible that there are creative behavior tasks that are better suited to individual creativity. One such task is the Remote Associates Test, which is a measure for convergent thinking (Mednick et al. 1964) that is most usually conducted with individuals, and not groups. The spaces, being open-plan work spaces, can accommodate more people doing work than just the participant. There was an obvious need to control for the presence of others, and logistical concerns for recruiting that many other confederates. Crowding has been shown to impact creative cognition (Maeng & Tanner 2013), so it is also possible that the room being mostly empty could have influenced the results of one or both creativity tasks. A future study that was conducted with participants in a more normally full work space would have more external validity. However, there are also times that an open workspace would be empty or less full than usual (early or late in the work day, or
over the weekend, for example). It would be interesting to examine moderating effects of the social environment on the physical environmental effects of creativity.

In contrast to Meyers-Levy & Zhu (2007), this study shows that the physical environment can have an impact on a person’s processing style regardless of the salience of the physical environment to the person. Meyers-Levy & Zhu (2007) found that ceiling height only had influence on a participants’ processing style when the ceiling height was made salient by hanging lanterns. In this study, I intentionally did not direct participants’ attention to any of the room features until the last survey task that inquired about their perception of the room. This makes the findings of this study more robust in a real world context: it is unlikely that most workplace features will be directly asked about or will be extremely salient to the people who work in them.

However, this research stops short of providing a mechanism for this effect. The proposed mechanism of the environment influencing exploratory seeking and novelty preference was not supported by this study. Other possible mechanisms may reside in the semantic priming effects shown in other studies (Aarts & Dijksterhuis 2003) or in embodied cognition effects of the homogeneous or heterogeneous layouts inducing certain body states (Meyers-Levy & Zhu, 2007, Maeng & Tanner 2012). Flexibility of the layout, or how much a person can move around and change their workspace, might have an embodied cognition effect on creativity, similar to the inhibited creativity shown by solving a problem “in a box” or walking in the shape of a box (Leung et al. 2012).

This research makes interesting strides towards showing the layout of an open workspace can impact the perceptions of what are appropriate activities for the space. Participants in the heterogeneous space condition were more likely to select unusual uses for the space when they did the similarity task first, followed by the brainstorming task. Said a different way, the
participants who did the brainstorming task closest to when they were asked to select activities for the space chose more unusual activities. This suggests that space perception, and the judgment of affordances for a particular space, are interactive processes between the physical elements of the space and the activities that are associated with it or that a person performs in that space. In this case, it is unclear whether the activity that came first drove the change in the unusual score for the space, or whether the activity that came second (and closer in time to the space use part of the survey) was what drove the change in space judgment.

This research also shows that space perception/judgment of affordances – in particular, preference for unusual space uses – is related to a persons’ self-reported preference for exploration and novelty seeking behavior. This is a connection that would be useful for the field of environmental psychology to study further. There is an interesting feed-back loop that might be present here: if you can influence exploratory behavior in a space, this in turn might make the person feel more curious and exploratory, and in turn they might view the space as able to support many different uses, and they might explore the space further and use the space differently.

Limitations:

The sample size was limited in this study. The availability of the room that the study was run in and the student population available to participate in the study were both limiting factors. A study with a larger sample size would increase the validity of this research.

A spatial limitation was the lack of natural light in the room. I closed the blinds in the room to control for light levels across different days that the study was run. However, the blinds that were present were blackout shades and most participants, after debriefing, commented that
they thought the room was without windows and this was something that they did not prefer.

Creativity potential has been linked with the presence of natural elements, such as textures and natural light (McCoy & Evans 2002). It is very possible that the lack of natural light, and the overall lack of natural elements in the space influenced the results of this study. Natural light and different types of lighting can influence the variability and differentiation of a space, and would be another layout factor to manipulate.

Another spatial limitation was the fact that in the homogenous condition, the tables were set up facing each other, whereas in the heterogeneous condition, the tables were not necessarily facing one another. This could’ve primed participants in the homogeneous condition to think in social, group, or competitive terms which would not have been present in the heterogeneous condition.

The homogeneous and heterogeneous dichotomy presented in this study as a way to categorize open plan layout has not been examined in terms of perceptions of space users. It is very possible that the homogeneous/heterogeneous dichotomy is perceived as conventional/unconventional, perceived as fixed/variable, or perceived as order/disorder. These perceptions were not included in the space and would progress the spatial typology literature forward. Another way to examine the categorizations of homogeneous and heterogeneous space would be to manipulate each factor separately to determine which one – variability, differentiation, or organic shapes – might influence creativity the most.

Another limitation of this study was that it did not address the previous experience of the participants’ with that particular room or with the concept of the “active learning classroom”. The large lecture class from which the majority of the participants were recruited was a multi-college class so participant experience with the Martha van Rensselaer building as well as with
that particular classroom were probably quite varied. It is quite possible that previous experience with the room and concept of the “active learning classrooms” might have influenced the results of the study.

There are numerous possible applications for this research in workplace and learning settings. In learning environments, these findings have interesting applications to active learning classrooms and learning spaces in which arrangements of furniture are easily changeable. The finding that layout can affect creative outcomes indicates that layout flexibility is a valuable consideration in these spaces. While more research should be conducted on the influence of layout on creative outcomes more specific to the workplace, this research has applications in the office. Offices that are more organic and less uniform may indeed be priming employees to think more abstractly and creatively.

The goals of this study were twofold: to work towards a categorization of open plan layout variables, as well as to begin the investigation of layout-level variables on creative cognition and creative behavior. This study made strides in both directions showing that the difference in homogeneous and heterogeneous layout impacted creative cognition. Layout-level variables are an often overlooked component of environmental psychology research and design strategy, and this study shows the importance of developing a deeper knowledge of the effects of layout on various work processes. In the following future research section, I design a future study to address that addresses the limitations of the current study and furthers the questions posed by this research.
FUTURE RESEARCH

A more comprehensive study on how layout affects creativity is called for. This future study will address the limitations outlined above, explore other possible mechanisms for how the physical environment affects creativity, and will separately manipulate the different elements of homogeneous/heterogeneous space. The research questions to be addressed in the future study are: how does past experience/associations (either creative or non-creative) with the room affect current creative behavior in the work setting? Is semantic and conceptual priming a mechanism for how layout affects creativity? Will there be a difference between conducting this study with the participant seated in the physical room or with the participant watching a video of the space? Are the three factors that contribute to the homogeneous/heterogeneous space spectrum equally important?

The proposed study will have six conditions. I propose a larger sample size at least double the current study, for a total of 60 participants per condition in the physical conditions. Using a service such as Amazon Mechanical Turk, it will be possible to get a lot of participants for the virtual space condition. While using Amazon Mechanical Turk will be beneficial for the sample size, it also introduces a lot of diversity into the sample. In the future study, extra demographics information will be collected such as specific age, specific occupation, and whether they currently work or previously worked in a creative field.

The three factors of the homogeneous/heterogeneous spectrum will be manipulated separately, as well as the study being conducted in both physical space and by showing a video of the space.
Table 5: Conditions for proposed future research

<table>
<thead>
<tr>
<th>High variability, physical space</th>
<th>High variability, virtual space</th>
</tr>
</thead>
<tbody>
<tr>
<td>High differentiation, physical space</td>
<td>High differentiation, virtual space</td>
</tr>
<tr>
<td>High organic shapes, physical space</td>
<td>High organic shapes, virtual space</td>
</tr>
</tbody>
</table>

Variability refers to how much the layout changes/differs in the space from one area of the space to another. To manipulate variability, furniture arrangements would be grouped in varying numbers, such as a couple tables together, and 6-8 tables together (Figure 6). Differentiation refers to the presence of partitions and half walls that break up the space into smaller nooks and areas. To manipulate differentiation, partitions such as portable white boards or folding screens will be placed in the room to create these smaller nooks (Figure 7). To manipulate rectilinear or organic shapes, tables and partitions will be arranged either in rows with 90 degree angles or circularly (Figure 8). In further future studies, it would also be possible to manipulate the furniture shapes.

The proposed study will use the same tasks as the current study, a similarity task as well as a brainstorming task. However, in the future study both the brainstorming task and the similarity task will be given 10 minutes duration, to control for time spent on the tasks and to give more time to the brainstorming task.

Video of the space should be done in a point-of-view manner of filming, such that the camera is “walking” slowly through the room to give the video viewer a comprehensive view of the layout and furniture arrangement.
Figure 6: Proposed layout displaying high variability

Figure 7: Proposed layout displaying high differentiation

Figure 8: Proposed layout displaying high level of organic shapes
Hypotheses for the future research are as follows:

H1: Past creative associations with the room will affect current creative behavior in the room.
H2: There will be no difference in creative outcomes between a person who is physically in the room and a person who watched a video of the room.
H3: Variability, differentiation, and organic shapes will have differential impacts on creative performance in the space.

Open-plan workspaces continue to be built with varying degrees of variability, differentiation, and organic shapes. This research proposes looking at open-plan layout with a new typology, of heterogeneous and homogeneous space. This new typology gives us a tool to systematically measure the effects of layout on important workplace outcomes such as creativity. We are aware from the creativity literature that spatial variables affect creativity, yet this is the first study to address layout-level variables in relation to creativity.

It is extremely valuable to understand layout effects: the layout of a workspace is one of the most variable spatial elements, as well as the one of the most easily changeable. This research study has taken the first step towards proposing a typology specific to open-plan layout, and towards constructing a research methodology that addresses layout in relation to creative outcomes.
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APPENDIX

Measures:

Categorization task

Identify as many dimensions that some or all items in this list share. Provide descriptive labels for the subgroups you create.

Soccer
Ping pong
Lacrosse
Hockey
Football
Baseball
Basketball
Softball
Volleyball
Tennis
Racquetball
Squash
Brainstorming task:

Consider the following scenario: After years of mismanagement and poor quality food, a university restaurant has finally gone bankrupt and is being shut down. The school administration is trying to decide what new business should go into that space. You will now have 5 minutes to generate as many ideas as possible on what new business should go into that space.
Rate the statements below for how accurately they reflect the way you generally feel and behave.

1 = totally disagree, 2 = disagree a little, 3 = neutral opinion, 4 = agree a little, 5 = totally agree

I often have new ideas
1 2 3 4 5

I am curious about many different things
1 2 3 4 5

I have a lot of imagination
1 2 3 4 5

I am inventive
1 2 3 4 5

I like artistic or aesthetic experiences
1 2 3 4 5

I have few artistic interests
1 2 3 4 5

I actively seek as much information as I can in new situations.
1 2 3 4 5

I am the type of person who really enjoys the uncertainty of everyday life.
1 2 3 4 5

I am at my best when doing something that is complex or challenging.
1 2 3 4 5

 Everywhere I go, I am out looking for new things or experiences.
I view challenging situations as an opportunity to grow and learn.

I like to do things that are a little frightening.

I am always looking for experiences that challenge how I think about myself and the world.

I prefer jobs that are excitingly unpredictable.

I frequently seek out opportunities to challenge myself and grow as a person.

I am the kind of person who embraces unfamiliar people, events, and places.

I enjoyed these tasks.

I was motivated to do these tasks.

I feel good at the moment.
1 = totally disagree, 2 = disagree a little, 3 = neutral opinion, 4 = agree a little, 5 = totally agree

This space is different from the normal space(s) that I work in.

1 2 3 4 5

I would choose to do work in a space like this one.

1 2 3 4 5

This space would support my work style.

1 2 3 4 5

I would not choose to work in a space like this.

1 2 3 4 5
Select what activities you would use the space for. Please check up to 10 activities.

Holding a meeting for a club/hobby
Creative workshop
Giving a lecture
Group work
Playing board games
Picnic
Individual studying
Working on a complex problem
Reading a book
Group studying
Host a reception
Gathering with friends
Holding a book group
Talking on the phone
Having a business meeting
Discussing world events
Watching a movie
Having a private conversation
Listening to a talk
Dinner party
Participating in a hackathon
Classroom activities
Brainstorming
Luncheon
Having a debate
Quiet work
Taking an exam
Working on a laptop
Teaching a class
What is your age group?
18-29
30-39
40-49
50-59
60-69
70-79

What is your gender?
Male
Female
Other

What is your occupation? _____________