Get the look you want: furniture arrangement affects intentional gaze towards behaviorally symbolic objects

Ray LC†
Northeastern University
College of Art, Media, and Design
Cornell Tech Information Science
New York, NY, USA
rl845@cornell.edu

ABSTRACT

Our perception of socially acceptable and relevant behaviors is influenced by factors like the environment we are in and the types of interactions that are possible. One of these factors is the arrangement of objects in a room. Is it possible that different arrangements of furniture in an otherwise identical room can change our perception of what can happen in the room and influence our behaviors without our conscious knowledge?

I created pictures of rooms with chairs arranged either all facing one direction towards a screen, or arranged in a circle centered around a circle. Participants' gaze is tracked while they are given a fixation point followed in turn by a picture of identical rooms save for the arrangements of an equal number of chairs. Viewers spent a significantly greater percentage of time gazing at the screen when the chairs were arranged in one direction, and a greater percentage of time gazing at the table when the chairs were arranged around a circle. The effect is equivalent to coloring the TV or table differently to make it stand out, which can lead gaze towards the emphasized object with similar magnitude to the chair configuration effect. The presence of windows in the scene does not affect the interaction, while an increase in the density of chairs changes the attention interaction from favoring the TV area when chairs are aligned, to the table area when chairs are in circle.

The results show that attentional gaze towards objects associated with human activities (TV for watching and table for discussing) is influenced by the arrangement of furniture that enable such activities. This suggests ways to subtly influence human behavior in a room by adjusting the configuration of furniture within it.

KEYWORDS

Machine influence, space design, implicit interactions, smart furniture, persuasive technology, machine communication.

† Correspondence and request for materials should be addressed to RLC (email: rl845@cornell.edu).

INTRODUCTION

Environment affects the way we perceive situations and perform behaviors. The space we inhabit and the way they are organized by furniture and interior design affects our perception and action. On the perception side, the presence of windows in visual representations of space affects social aesthetics and the mood of the viewers (Kaye, 1982). On the behavioral side, the design of interiors like an office can promote differing levels of perseverant behavior by the use of room partitions (Roberts, et al, 2019). Even cognitive factors like creativity and productivity have been linked to feelings of freedom or confinement enabled by movable walls and furniture that support small or big groups (Taher, 2008).

To study how environmental variables like furniture configuration affects behavior, we used eye tracking to examine how subjects' gaze at behaviorally relevant key objects in a scene can be redirected in differently arranged rooms. Previous work has shown that the shape of seating arrangements in a room (angular vs circular) affects how persuasive individual-oriented and family-oriented endorsement information can be (Zhu & Argo, 2013). Other work finds that corner-table seating arrangements produces greater subject interaction than opposite-facing and side-by-side facing seating, and that subjects will choose rounded corner seats for purposes of discussion over other configurations (Sommer, 1959). Thus seating arrangement is likely to affect the way participants perceive the scene and think about future interactions within the scene.

By studying the way people gaze at the two different landmarks of TV and table in a scene, we can infer implicit human objectives when they view the scene. The TV screen is associated with paying attention to a common source of interest, while the coffee table is associated with discussions and social activities. If the arrangements of chairs can modulate these differing attention-inferred objectives, the chairs would serve as a source for possible implicit interactions with humans that influence their behavior by the way they are positioned (Ju, 2015). By understanding the geometric cues that can influence human attentional and behavioral processes, chairs may serve as machines that modulate human interactions without human conscious intervention.

METHODS

I first designed the collection of photos with the view of capturing the variabilities relevant to gaze behavior in a room with a TV and a coffee table. One study showed that variance in human evaluations of physical properties of classrooms can be explained by the three variables of view of outdoors, comfort, and seating arrangement (Douglas & Gifford, 2001). Thus in addition to varying the configuration of the chairs in either facing the same direction or in a circle, I varied the presence of window vs. solid wall and the density of the chairs in the room.

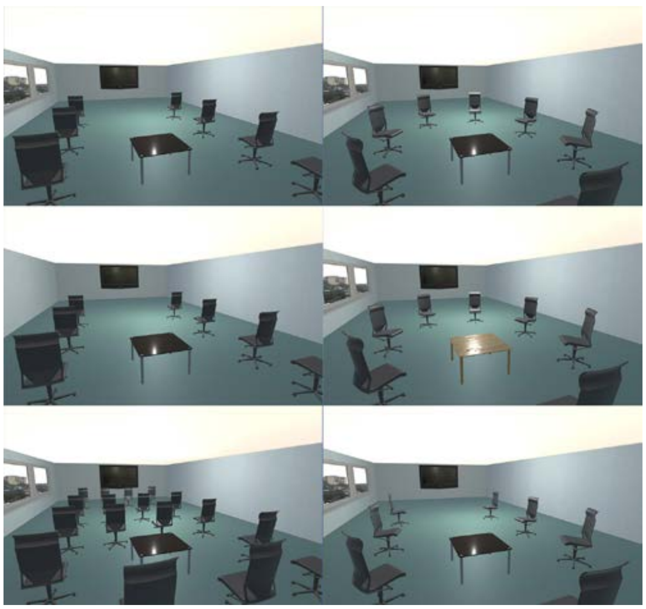

Figure 1: Examples from the stimulus set totally 15 images. (Upper left) Aligned chair condition. (Upper right) Circular chair condition. (Middle left) Aligned condition with no window. (Middle right) Circular condition with emphasized table. (Lower left) Aligned condition with high chair density. (Lower right) Semicircular chair configuration condition.

In addition, I created additional conditions of having different colored TVs (that are on) and different colored tables (Figure 1). The idea is that they would emphasize those particular objects in the scene, serving as a control way of directing gaze attention to them. Finally, I added an intermediate condition between total alignment and totally circular arrangement called the semicircular arrangement. I reasoned that such a configuration should support both gaze to the TV and the table, serving as an intermediary control for the aligned and circular conditions. All renderings were done from the same camera location on an Unity scene with assets from the Vertex Studio furniture pack. The TV and table were measured to have the same screen area.

Experiments were run using IMotions 7.0 software to track gaze using a Tobii X2 30Hz eye tracker and facial expressions using a webcam and the Affectiva Affdex SDK. 8 students (2 female) from Northeastern University College of Art, Media, and Design participated in the study (Figure 2). Each subject was asked to fixate on a cross before presentation of each stimulus image, and to subjectively score on a scale of 1 to 5 how pleasant the scene depicted is in their mind. This was to make sure they are not consciously controlling the gaze, but is rather involved in some unrelated task while their eyes wander around the scene. 15 stimuli were each presented for 5 seconds after a 5 second fixation cross period for each image. The stimuli groups were Chair Aligned, Chair Circular, and Chair Semi-Circular conditions, each of which include the Normal Stimulus, Emphasize Table, Emphasize Chair, No Window, and High Density conditions. Participants were given each of the 15 stimuli in random order, given a rest period of 3-5 minutes, then presented with a reversed order of the stimuli, with the two result averaged.

Figure 2: Usability lab setup for an experiment monitoring viewer gaze while the participant gives a mental ranking on the scene she has just been shown on the computer.

In the eye tracking analysis, the TV and table areas were drawn as Areas of Interest (AOI), and the time spent and percent time spent in the AOIs by the gaze points are calculated. Number of fixations in each condition in each AOI is also calculated, along with metrics like revisits (an indicator of confusion or sustained attention or frustration), ratio of participants who looked at the AOI, first and average fixation duration, and gaze heat maps. IMotions 7.0 software suite are used for the AOI marking and video of eye movements. The unprocessed results for each AOI in each condition are downloaded and analyzed in R 3.6.0.

RESULTS

Main Effects in Gaze

Example individual gaze maps are shown in Figure 3. Note the concentration of gaze in the table, TV, chair, and window areas. Example heat maps of grouped data is in Figure 4. To assess if the time spent gazing is affected by the location of the gaze (aoi factor) and the way chairs were placed in the scene (config factor), we first performed two-way ANOVA on only the subset of data with only the aligned config and circular config conditions without any other factors like density and window. Results show only significant interaction aoi:config (F=10.051, df=1, p=0.00367), and not aoi nor config by itself (Figure 5). The interaction plot shows that the biggest differences come when the chairs are aligned, in which case gaze to the TV is 15% more likely than to the table (upper right). Moreover looking at the TV is almost 15% more likely when the chairs are aligned than when they are circularly arranged (lower left). The trend is reversed for the table, making the interaction significant.

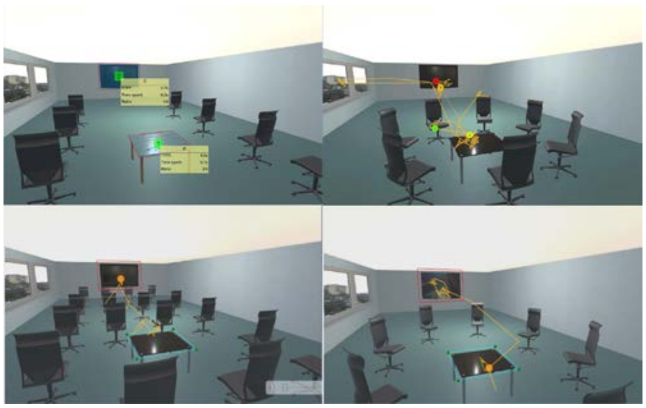

Figure 3: Example gaze traces for a subject showing eye tracking during the course of 5 second stimulus presentation. Defined areas of interest (AOI) on TV and table (upper left). A high density circular config where majority of time is spent on the table vs. TV and window (upper right). A high density aligned condition with fixation on TV (lower left). A regular density circular config with fixation on the table (lower right).

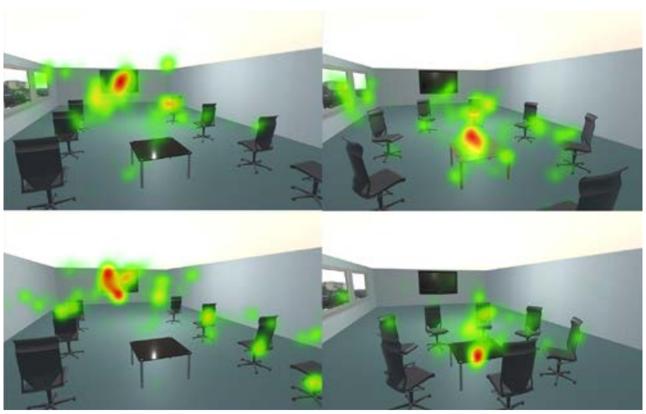

Figure 4: Example heat maps of grouped gaze activity during the course of 5 second stimulus presentation. Regular aligned config (upper left). Table-emphasized circular config (upper right). Window-less aligned condition (lower left). High chair density circular config (lower right).

Next we examine the regular condition data that includes the semi-circular config, and found that again only aoi:config interaction is significant (F=6.698, df=2, p=0.00299). The semi-circular config led to about equal amount of time spent between TV and table conditions, fashioning itself as a control level between aligned and circular configs (Figure 6-7). Semi circular config also serves as a control for chairs facing the AOIs. In both aligned and circular conditions, chairs face the AOI with greater percent time spent, but in semi circular config, the chairs as a group face both the TV and the table AOIs, removing that bias.

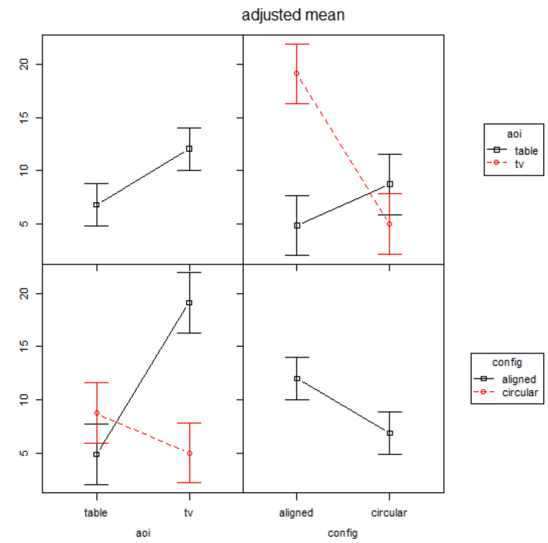

Figure 5: Interaction plot of percent time spent as a factor of aoi (TV or table) and config (aligned or circular) shows a gaze preference for TV when the chairs are aligned, and for table when the chairs are in a circular arrangement.

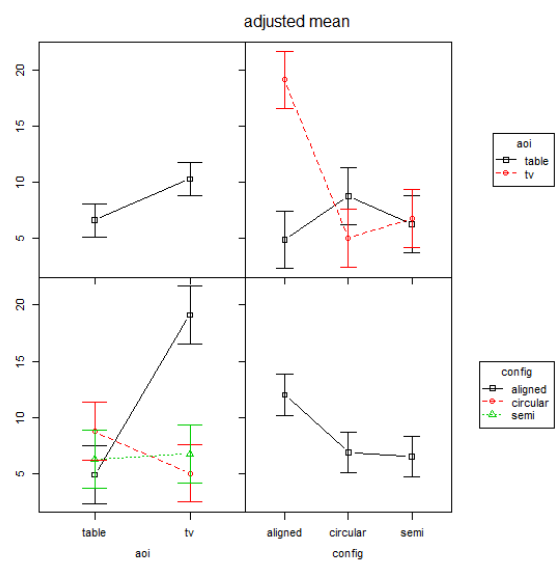

Figure 6: Interaction plot of percent time spent as a factor of aoi (TV, table) and config (aligned, circular, semi circular) shows no AOI gaze preference in the semi circular condition.

Posthoc comparison (Tukey) reveals a significant difference between tv:aligned vs. table:aligned (p=0.0040745), showing that subjects are more likely to look at the TV if the chairs in two rows are facing the wall containing the TV. The tv:circular vs. tv:aligned comparison is also significant (p=0.0045019), showing a difference in the way gaze is directed towards the TV when chairs are arranged in a circle around the table as opposed to aligned towards the wall. The table:semi vs. tv:aligned (p=0.0118714) and tv:semi vs. tv:aligned (p=0.0172216) are the only other significant comparisons, showing that the bias for TV AOI in gaze in aligned config is not due only to the chairs facing the TV, for in the semi circular condition the chairs also look at the TV from each side, but there's no preference for gazing at the TV. Thus there's something about the *alignment* of the chairs that affected gaze. Individual conditions are not significant posthoc.

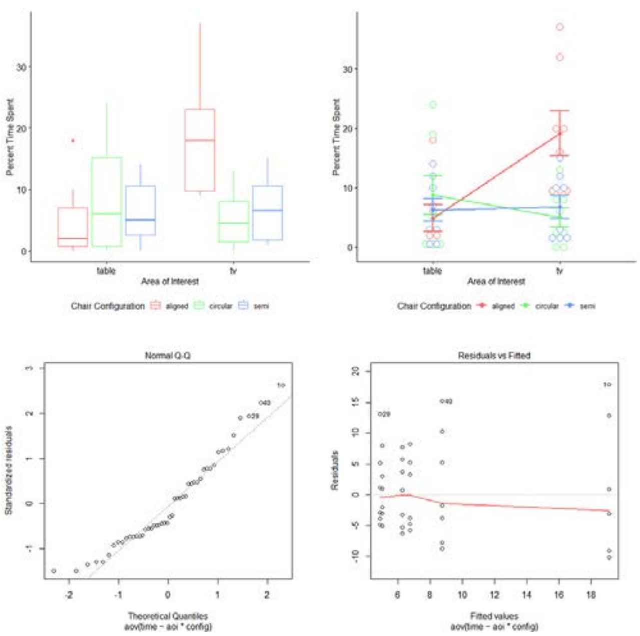

Figure 7: Boxplot (upper left) and line plot (upper right) of the full data in Figure 6, showing significant interaction in aoi and config. Normal Q-Q plot of residual quartiles vs. normal quartiles (lower left). Residuals plotted against fitted value in the ANOVA model, showing random dispersion (lower right).

Testing Assumptions

In using two-way ANOVA, we assumed random sampling (by computer stimulus delivery) and independent observations (by having fixation cards before every stimulus). To have confidence in our ANOVA results we test the assumptions of equal variances between the groups and normality of the data (Figure 7).

Residuals are plotted against values fitted, with data appearing both above and below zero, indicating that the homogeneity of variances assumption has not been violated (Levene test, p=0.2683). The data also appear to fall roughly in a line in a Normal Q-Q plot against Gaussian quartiles, suggesting that assumption of normality has not been violated.

Intervening Factors

To see if the presence of a window affects the aoi:config interaction, I performed a three-way ANOVA using expanded data containing window and no window (solid) conditions. Only aoi:config is significant ($F=13.618$, $df=2$, $p=7\text{x}10^{-6}$), showing that the presence of windows does not affect AOI-chair config effects.

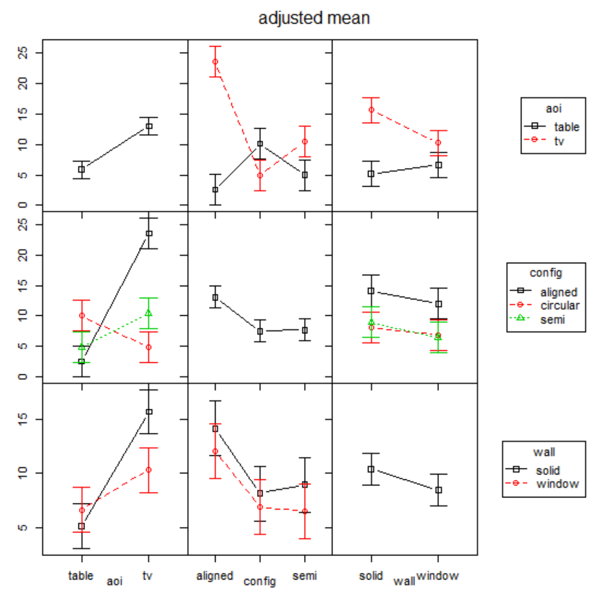

Figure 8: Presence of window does not affect AOI-chair config interaction. Same direction of effect based on AOI (upper right) and config (middle right) regardless of window or solid.

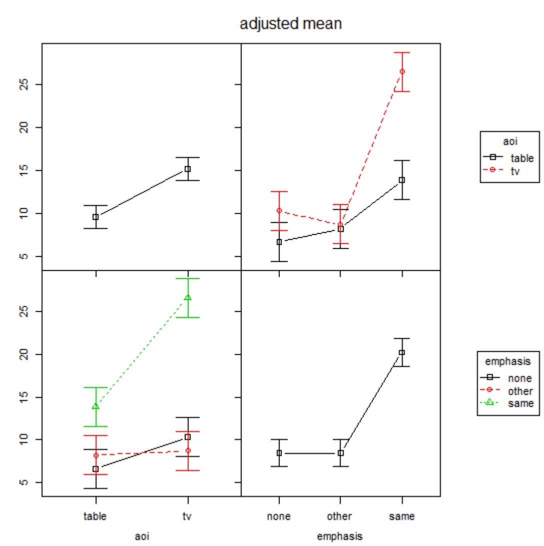

Figure 9: AOI interacts with whether the area is emphasized using another color (lower left). When the AOI is emphasized (same), percent time spent is increased, but more so for TV.

To see if emphasizing an AOI using a color change can increase time spent gazing it, and whether this can rescue the lowered time spent when the chair config is incongruent (for example table when chairs are aligned), I performed a three-way ANOVA on the data that include AOI emphasis (color) changes. In addition to the expected significant interaction aoi:config ($F=6.824$, $df=2$, $p=0.00154$), I saw significance in aoi:emphasis ($F=3.817$, $df=2$, $p=0.02459$), but not in aoi:config:emphasis, suggesting that coloring the TV AOI is more effective in garnering gaze attention than coloring the table AOI. Indeed posthoc test (Tukey) reveals a significant difference in TV:same vs. table:same ($p=0.0019656$), meaning that gaze time at the TV AOI when it is also the AOI emphasized is significantly higher than gaze time at the table when it is also the AOI emphasized.

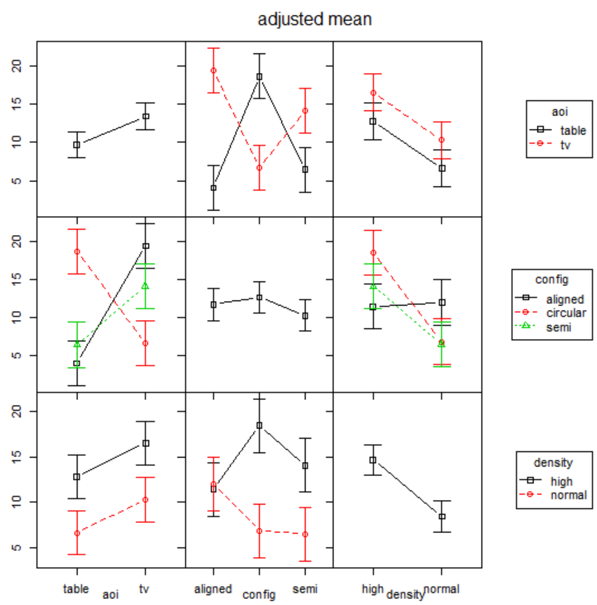

Figure 10: Density of chairs affects percent time spent in AOIs (lower right). A trend showing density may affect circular and semi-circular configs to a greater extent than aligned (middle right). AOI interacts with config (middle left).

Beyond interactions, the analysis shows that emphasizing the AOI using coloring increases percent time spent gazing at that AOI by about the same amount as that gained from chair arrangement (just under 15%, Figure 9). This makes emphasizing an AOI an effective means of raising gaze time when the AOI and chair config are incongruent. For example, in the aligned config, percent time spent in the table AOI is down to 4.875%, because the gaze is directed in a goal-directed manner toward the TV. However by emphasizing the table, the percent time spent in the table becomes 13.25%, overcoming the reduction in gaze. Similarly in the circular arrangement, TV is gazed at 5% of the time, but by emphasizing TV, gaze time goes up to 22%, which is similar to the effect of having TV in an aligned config (19.125%). Thus aligning the chairs has an effect on attention at the TV that is equivalent to coloring that TV differently to make it stand out.

Next we examine whether varying the density of the chairs affects percent time spent in gaze for particular AOIs and configs. Three-way ANOVA shows that high density arrangements increase time spent gazing ($F=6.657$, $df=1$, $p=0.0116$), but that this affects TV and table AOIs similarly (Figure 10). Surprisingly we found a 3-way interaction aoi:config:density ($F=3.473$, $df=2$, $p=0.0356$). This means the way gaze occurs in an AOI in different chair configs is modulated by the density/number of these chairs.

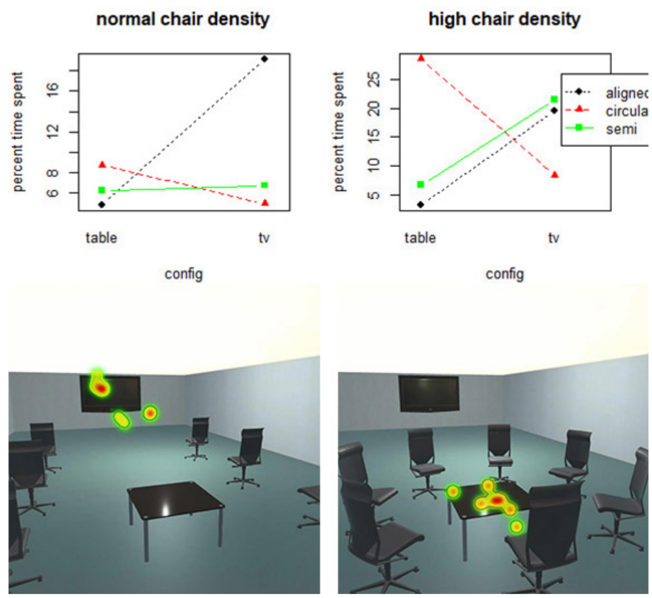

Figure 11: Density of chairs affects the way AOI interacts with chair config. In normal density, TV area is affected most by config change to aligned arrangement (upper left). In high density situation, table area is affected most by config change to circular arrangement (upper right). Example aggregate gaze heatmaps in normal (lower left) and high density (lower right) conditions for aligned and circular conditions.

Thus I ran separate two-way ANOVAs on the high and normal density data, the latter equivalent to a prior analysis (Figure 6). In both cases there are significant interactions aoi:config ($p=0.00299$ in normal, $p=0.00147$ in high density), but the three-way result suggests that the interactions are different in normal and high density. Indeed, while in normal density, greatest gaze time occurs with TV AOI in aligned condition; in high density, greatest gaze time occurs with table AOI in circular arrangement (Figure 11). This shows that the number and density of chairs in a scene can affect the strength of the interaction, and even shift the interaction to favor certain AOIs. In this case I postulate that the proximity of the chairs to the table is a stronger determinant of gaze attention than simply stacking more chairs in alignment, because it makes the semantics of the implicit conversation/meeting goal stronger.

Effects in Fixation

Since the number of fixations is small and sporadic, I looked at the number of eye fixations at each AOI and config by summing across the participants in the entire data and running a two-way ANOVA. There were significantly more fixations on the TV ($F=16.475$, $df=1$, $p=0.000454$), mostly due to its prominence in aligned and semi-circular chair arrangements (Figure 12). There was also significant interaction between AOI and config ($F=3.982$, $df=2$, $p=0.032097$), with post hoc significant differences tv:aligned vs. table: aligned ($p=0.0034245$), and tv:semi vs. table:aligned ($p=0.0047273$).

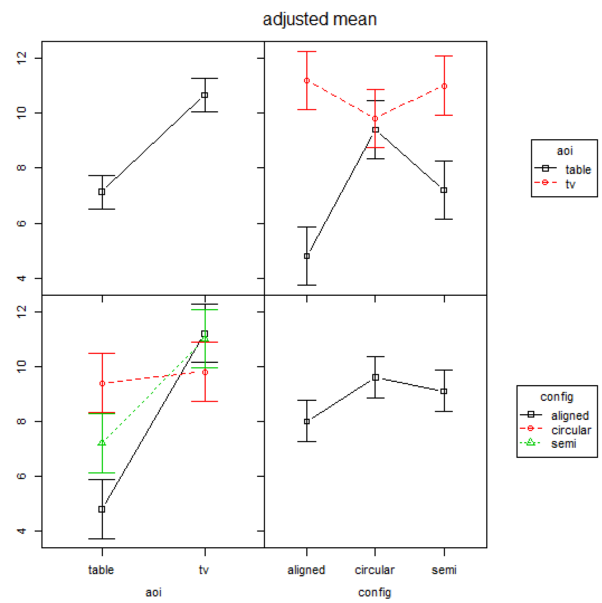

Figure 12: Eye fixation are more common in TV over table AOIs (upper right). There are fixations on TV in any config, but graded number of fixations on table according to whether the chairs are arranged to encircle it (lower left).

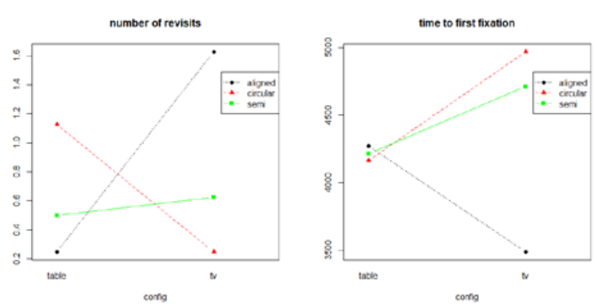

Figure 13: Number of revisits to an AOI is affected by chair arrangement, with no preference in semi-circular config that lies intermediary between aligned and circular configs (left). TTFF is only affected by TV AOI in different configs (right).

Fixations are common on the TV regardless of the config, but only common on the table when the chairs are arranged on circle (or semi-circle) around it. This suggests that, unlike the percent time of gaze, number of fixations can predict only whether participants lock onto the table depending on how the chairs are arranged. This is consistent with the previous result showing that emphasizing the TV by color has stronger effect than emphasizing the table. The TV may have intrinsically more staying power, which doesn't give way unless the chair density is high.

I didn't find significant differences in first fixation duration, average fixation duration, response ratio, nor time to first fixation (TTFF) between TV and table AOIs, although there's a trend in TTFF of having no variability between configs in table AOI but fast TTFF in aligned config in TV AOI, suggesting a greater subconscious salience of TV in the chair aligned condition. However, there was a significant interaction aoi:config in the number of revisits by the gaze ($F=4.302$, $df=2$, $p=0.020$). Revisits of gaze typically point to area of confusion, surprise, or attraction. Our results show that analogous to the gaze time result, revisits are most common to the TV in aligned config, and to the table in circular config, showing that there's persistent interest in these areas in situations congruent with chair arrangements (Figure 13).

Effects in Facial Features

In addition to eye tracking, we used Affectiva's Affdex to detect facial features that may tell us about emotional processing during different trials in the experiment. For our purpose we looked at percent engagement, percent attention, and percent eye closure. When comparing aligned vs. circular arrangement trials on each of these face metrics, we see no significant difference in facial engagement expression, attention, or eye closure between the chair configurations. The closest is the aligned emphasized table condition vs. circular emphasized table ($p=0.148904$). This means that the trials with different pictures themselves do not affect facial expression, attention, and whether eyes are opened by themselves. Rather it's the interaction of the AOI with particular conditions illustrated in the photos that capture visual attention in gaze and fixation.

DISCUSSION

Perceptual Effects of Chair Arrangements

The way rooms are arranged subtly influence us, both in terms of what we look at, and also what we perceive to be the core function of an environment. This study shows that chair arrangement affects attention of human gaze to targets that symbolize particular functions of a room. In a room with both a TV and a coffee table, chairs aligned all facing the wall the TV is on focused gaze to the TV, implying a perception of the context as for presentation, or watching video. Meanwhile Chairs arranged in a circle around the table shifted attentional gaze to the table, as perception shifts to discussion, meeting, and socialization.

This interaction of TV:table AOI with aligned:circular chair config is not affected by whether windows are present in the scene, but emphasizing an AOI by coloring it differently has a greater effect on the TV AOI. In incongruent AOI-config conditions, emphasizing the AOI raises it to congruent AOI-config gaze percent times, showing that alignment of chairs has about the same effect as coloring the AOIs to make them more conspicuous for gaze. When chair density is normal, most of the effect comes from gaze to the TV in aligned config, but when chair density is high, the interaction comes more from gazing to table in circular arrangement, possibly due to the proximity of chairs to the table all becoming shorter in addition to being more numerous.

Interaction effects persists in fixations in addition to the gaze times, with most effect coming in this case due to difference in fixating to the table in different chair configs. This could be due to higher gazing to TV overall, which means gaze to the table only reveals itself to be different as a fixation effect, or for different configs at high chair density. Revisits to AOIs also interact with chair config, indicating persistent attention and possible source of confusion or frustration. Finally lack of effects on facial expression between different conditions indicates that participants reacted similarly to different configs, and differences in gaze are not attributable to emotional and engagement factors during the course of the trials.

Relations to Social Robotics

The design of interiors affects perception and intention, and in some studies, it has been found to affect human behavior. In one study, rearrangement of room furniture led students to move to different areas of the class, using tools they would otherwise not have used (Weinstein, 1977). This work has led to call for creative environments using movable benches, tool containers, and cabinets that can be shared and adapted for use by multiple groups (Warner, 2010). Given our findings, we expect that arrangement of chairs can be used to promote certain behaviors as well, not just affect perception. If given no prior directives, people may be expected to sit around the coffee table and chat if the chairs are put in a circle around the room. The current study shows that such behaviors may originate with remappings in perceptual attention.

Having chairs in a room affect people is only one side of the equation, for people move chairs around when they're in a room. This causes the room to resemble what people want to happen over time. Can we take the initiative away from humans and affect them by giving agency to the chairs themselves? One way is design gestures undertaken by chairs to make them robots with their own intentions that can affect humans. One study used different physical chair gestures (shaking left and right, subtle pause, moving back and forth) to get humans to move out of the way as the chair steps forward pass them (Knight et al, 2017). They found that back and forth movements best influence human yielding behavior, showing that clear communication strategies that don't overly interrupt equip these robots for influencing human behavior.

A flip side to the idea of overt influence is to design social robots like chairs to persuade subconsciously, which one study terms Mindless Computing (Adams, 2015). In contrast to affecting conscious processing like goal-setting and self-monitoring which rely on inconsistent human motivation and self-control, the approach relies on "non-interrupting" reflexive interventions that run in parallel to other cognitive systems to trigger human behaviors much as in daily life, so as to not burden the human to too much information. Studies have shown that implicit instructions are more likely to effectively influence humans. One group of participants were instructed to not play wit a robot toy because it is "bad," while another group was told only to be "aware" of the toy before experimenters left the room. The group given explicit instructions actually spent more time playing with the robot in the experimenter's absence than control while the implicit instructions group played with the robot less than control. In the context of chair robots, this suggests subtle interactions like small imperceptible movements when the humans are not around, such as remapping from a conference room to a social gathering space when humans are going to the restroom.

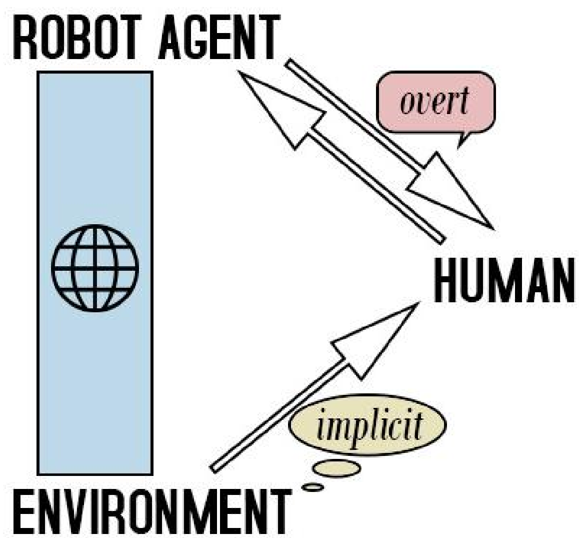

Figure 13: Environment Support Model for human-robot interaction. Humans give instructions and receive feedback from robot agents, expecting the robot to behave with social robotic norms, but in reality the agent communicates with or changes the environment to effect implicit influences on the human. In the context of chair robots, they make changes to the environment by moving themselves in different alignments to support perceptual changes that lead to behavioral results.

Environment Support Model

To synthesize two view points of explicit and implicit interactions with robotic agents, we propose a model that puts up a front of robotic interactions that people are most familiar with. Humans are used to asking robotic agents to do things and getting feedback in return. While interacting with humans overtly like making gestures and producing items, the robot agent actually communicates with the environment or uses effectors to change the environment in subtle ways, so that it can leverage persuasive technologies to nudge humans to do good. Since as we have shown, human perception of what spaces are for and what interactions are possible are colored by what they see in the environment, robotic modification of these subtle environmental perceptions can change human behavior.

Effective Gestures and Supports

The Environment Support Model and social robotics in general relies on effective gestures from robots that can communicate effectively with human perceptions. How do we design these gestures beyond postulating and testing numerous alternatives? One approach uses crowd sourced data from humans to make robots more effective. One study used this process of data-driven robot behavior generation in collaboration with human heuristic planning in a "Mars Escape" game with another player, showing that in-the-moment interpersonal dynamics greatly affects the quality of the interaction (Breazeal et al, 2013). Asking human players to judge different human gestures on, for example Amazon Turk, allows the system to model ideal interactions based on complex human data, relying on data methods like machine learning to produce interactions optimized for likelihood for success.

In addition to relying on human data, we also need to be sure that the study takes place in a human-based environment. The research detailed so far takes place mostly in the lab, but people will use robots in complicated social settings. One study calls for human robot interaction labs to go to workplaces, homes, and public arenas to study the complex dynamics involved when robots are asked to work with multiple people (Jung & Hinds, 2018). They argue for an understanding of robots in imperceptible contexts where their involvement follows complex rules of social interaction inherent in the public domain.

The intention of the human in HRI is investigated in one paper that uses a theory of mind kept track of by the robot to infer the human's plan and whether the human needs help (Gorur et al, 2017). The robot and human make collaborative decisions, with the robot calculating a probabilistic model of the human's intention, making its actions less intrusive and more appropriate.

Given the vast research on how environments affect human perception and behavior accumulated throughout the years (Drew, 1971), it is easy to envision strategies to enable robots and environments working together to affect human outcome for positive behavior. We have shown that human attention and perception is affected by the design of environments and arrangement of agents in the scene. We argue that the attention paid to symbolically important objects in the scene suggests that behavioral modification is possible using strategies to subtly change the environment. This and other studies suggests that artificial agents can communicate with humans based on environmental influences, and that humans will perceive these influences with different efficacy depending on context and motivation. Furniture that interpret human response and use gestures to communicate will make environments more amenable to bidirectional communication with humans, and to influence them to respond in positive ways.

ACKNOWLEDGMENTS

The author would like to thank Sven Travis and Loretta Wolozin (Parsons), Wendy Ju (Cornell Tech), and Judith Hall (Northeastern).

REFERENCES

[1] Adams, A. T., Costa, J., Jung, M. F., Choudhury, T. Mindless computing: designing technologies to subtly influence behavior. (2015). *Ubicomp*. 15.
[2] Breazeal, C., DePalma, N., Orkin, J., Chernova, S., and Jung, M. (2013). Crowdsourcing human-robot interaction: new methods and system evaluation in a public environment. *Journal of Human-Robot Interaction*. 2 (1): 82-111.
[3] Douglas, D., and Gifford, R. (2001). Evaluation of the physical classroom by students and professors: A lens model approach. *Educational Research*, 43(3): 295-309.
[4] Drew, C. J. (1971). Research on the psychological-behavioral effects of the physical environment. *Review of Educational Research*. 41 (5).
[5] Gorur, O. C., Rosman, B., Hoffman, G., and Albayrak, S. (2017). Toward integrating theory of mind into adaptive decision-making of social robots to understand human intention. *International Conference on Human-Robot Interaction*. 17.
[6] Jung, M., and Hinds, P. (2018). Robots in the wild: a time for more robust theories of human-robot interaction. *ACM Transactions on Human-Robot Interactions*. 7 (1) 2.
[7] Kaye, S. M., and Murray, M. A. (1982). Evaluations of an architectural space as a function of variations in furniture arrangement, furniture density, and windows. *Human Factors*. 24(5): 609-618.
[8] Knight, H., Lee, T., Hallawell, B., and Ju, W. (2017). I get it already! The influence of chairbot motion gestures on bystander response. *IEEE International Symposium on Robot and Human Interactive Communication*. 26: 443.
[9] Ju, W. (2015). *The Design of Implicit Interactions*. Morgan & Claypool: Penn State, USA.
[10] Roberts, A. C., Yap, H. S., Kwok, K. W., Car, J., Soh, C. K., and Christopoulos, G. I. (2019). The cubicle deconstructed: Simple visual enclosure improves perseverance. *Journal of Environmental Psychology*. 63: 60-73.
[11] Sommer, R. (1959). Studies in personal space. *Sociometry*. 22: 247-260.
[12] Taher, R. (2008). *Organizational creativity through space design*. Buffalo State College: Buffalo, NY, USA.
[13] Wardono, P., Hibino, H., and Koyama, S. (2010). Effects of interior colors, lighting and decors on perceived sociability, emotion and behavior related to social dining. *Asia Pacific International Conference on Environment-Behaviour Studies Kuching*. 38: 362-372.
[14] Warner, S. A., and Myers, K. L. (2010). The creative classroom: the role of space and place toward facilitating creativity. *The Technology Teacher*. 28-34.
[15] Weinstein, C. S. Modifying student behavior in an open classroom through changes in the physical design. (1977). *American Educational Research Journal*. 14 (3): 249-262.
[16] Zhu, R., and Argo, J. J. (2013). Exploring the impact of various shaped seating arrangements on persuasion. *Journal of Consumer Research*. 40(2): 336-349.