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Evidence-Based Ergonomics. A Comparison of Japanese and American Office Layouts

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There is a variety of alternatives in office layouts. Yet the theoretical basis and criteria for predicting how well these layouts accommodate employees are poorly understood. The objective of this study was to evaluate criteria for selecting office layouts. Intensive computer workers worked in simulated office layouts in a controlled experimental laboratory. Eye movement measures indicate that knowledge work requires both concentration and interaction. Findings pointed to one layout as providing optimum balance between these 2 requirements. Recommendations for establishing a theoretical basis and design criteria for selecting office layouts based on work style are suggested.

evidence based ergonomics design work style eye movement

1. INTRODUCTION

1.1. Japanese and American Office Design

Advances in information technologies have fundamentally changed living and work environments (Kincaid, 1999; Weinstock, 1994). Office technologies have affected both the organization of work and the design of work places.

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There was an open office movement for a completely open office, Burolandshaft, which was started in Germany in the 1950s. Herman Miller introduced what they called the Action Office open plan system in the 1960s. The concept of flexible offices was introduced in Sweden in 1990 (Brunnberg, 2000).

Of course, office layouts vary in this respect by degree. At the extreme, offices are in continuous movement. The paperless office and the mobile phone have facilitated flexible work processes.

In recent years, call centers have received particular attention, especially in Europe. Benninghoven (2002) wrote that the limitations in office design and layouts have had a negative impact on the work environment and equipment in call centers. Correspondingly, he suggested that these workspaces were often inadequate.

In the USA and in Europe, these issues have generated interest in rethinking office layouts and in developing a new office layout that better reflects organizational changes in work and technologies. Office furniture makers in the USA produce workstations and furniture systems that support office layouts that reflect the employee's work style and profession.

These writers suggest that office buildings in the U.S. market vary, but they resemble those found in Japan.

Noro and Tanaka (2001) hypothesized that, in general, Japanese organizations have shown little intent or interest in moving away from antiquated island-style layouts. These writers concluded that it was critical that organizations in Japan begin to make this shift toward modified American-style office layouts in order to support new ways of working.

1.2. Organizational Context in Japan

Japanese organizations are at a critical juncture. Flat (nonhierarchical) organizations generally require highly productive intensive knowledge workers. The transition from rigid and hierarchical to flexible and nonhierarchical organizational structures is difficult for Japanese companies because they tend to adhere to hierarchical organizational structures, work places, and office layouts.

Japanese offices traditionally adopt island-style layouts (see Figure 1). The most prominent feature of the Japanese island-style office layout is that each group forms an island, with the group leader at a prominent position. Even today, most companies continue to use this style in spite of the changes in the nature of work.

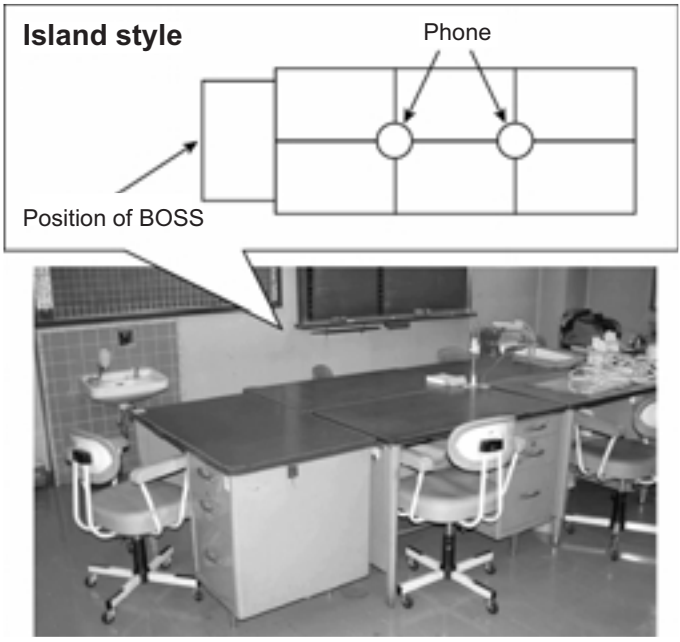

Figure 1. Japanese island-style office layout.

Japanese offices have traditionally adhered to island layouts because these reflect the Japanese style of teamwork and top-down style of management. Although information technologies have changed the work process, they have had little impact on the physical layout of Japanese offices[1].

One advantage of the island layout is that it saves space. The disadvantage is that it does not support increasingly critical knowledge work. Such issues underscore the importance of clarifying the theoretical basis and design criteria for evaluating office layouts.

Of course, this requirement is not relevant to Japanese organizations only. Guimaraes, Fogliatto, and Belmonte (2000) reported that in Europe and in the USA, computer video syndrome has become a predominant complaint of intensive computer users. These writers emphasized that such problems were largely caused by bad workstation design. This suggests that today's knowledge workers must work with improper workstations, equipment, and layouts.

The purpose of this study was to analyze the theoretical basis and design criteria for selecting office layouts that reflect the worker's work style and profession.

[1] Because the Free Address office was developed in Japan, a reform of offices adopting Information Technology seems to be in demand in Japan.

2. METHODOLOGY

2.1. Evidence-Based Ergonomics and the Live Office for the Experiment

Such demands are particularly pronounced in the field of health care. Research on evidence-based health care has generated interest internationally (Jack, Roberts, & Wilson, 2003). This present study incorporated the evidence-based focus.

Although laboratory environments obviously provide an opportunity to control experimental conditions, they also differ from actual office work situations, sometimes in potentially meaningful ways. For this reason, the experimental condition should correspond to the actual working condition where feasible.

Petrelius (2000) described a distance working laboratory that was referred to as the Live Ergonomic Environmental Office Lab. This lab represented a fully functional office work place with about 10 office workers.

Our study represented a similar attempt, aimed at recreating a fully functioning office that reflects the evidence-based ergonomics focus.

2.2. Previous Research

Numerous studies have focused on the psychosocial issues related to the office. For example, Robertson, Robinson, and Chen (2000) described an office ergonomics intervention that enhanced worker health, well-being, and organizational effectiveness. Some studies assessed the effectiveness of an office ergonomics training program (Lewis, Krawiec, Confer, Agopsowicz, & Crandall, 2001; Robertson & Robinson, 2000). Andersson, Berns, and Klusell (2000) developed a testing tool for office work places. Guimaraes et al. (2000) studied motivational issues in the work environment, and Kestler and Romero (2000) researched complete ergonomics assessments of offices by using the Internet. Noro and Tanaka (2001) classified workers into four groups, using an autonomy versus interaction matrix. Based on this concept, Pregnolato (2003) reported research on a call center in Italy.

2.3. Autonomy and Interaction

Before starting the study, employees were categorized based on an autonomy and interaction matrix developed by Noro and Tanaka (2001) and described in a product catalogue (Steelcase, 1997).

Autonomy and interaction were defined as follows (Noro & Tanaka, 2001):

- Autonomy depends on the individual how, where, or when to work;
- Interaction expresses the frequency of necessary exchanges with others in the process of accomplishing work.

2.4. Focus of the Analysis

Noro and Tanaka (2001) suggested that high-interaction and high-autonomy workers must accommodate a range of tasks simultaneously yet concentrate on the primary task. Correspondingly, this study focused particularly on the dimension of concentration.

3. EXPERIMENT

Common measurement methods used in office ergonomic research include interviews and questionnaires (Petrelius, 2000). Macroergonomics research that analyzed participatory approaches generally incorporated these techniques (Guimaraes & Linden, 2000; Matarazzo & Graziano, 2000; Robertson et al., 2000).

The use of objective measures such as physiological measurements is much less common in office ergonomics. Brand et al. (2000) installed blood flow measurement in the study of an office chair. Noro and Tanaka (2001) measured pelvic angle, eye movement, and heart rate for a psychophysiological evaluation of the workers.

3.1. Participants

The participant was an intensive knowledge employee who worked in research and development. Intensive knowledge workers are classified as high autonomy and high interaction workers in Noro and Tanaka's (2001) research.

3.2. Experimental Office

An experimental office system with removable partitions was installed in a laboratory simulation of an office. The designer of this office system indi-

cated that the Japanese shoji (a sliding paper screen) inspired the removable partition. This furniture product enabled a variety of office layouts by reconfiguring the screens. Figure 2 depicts the office used for the experiment.

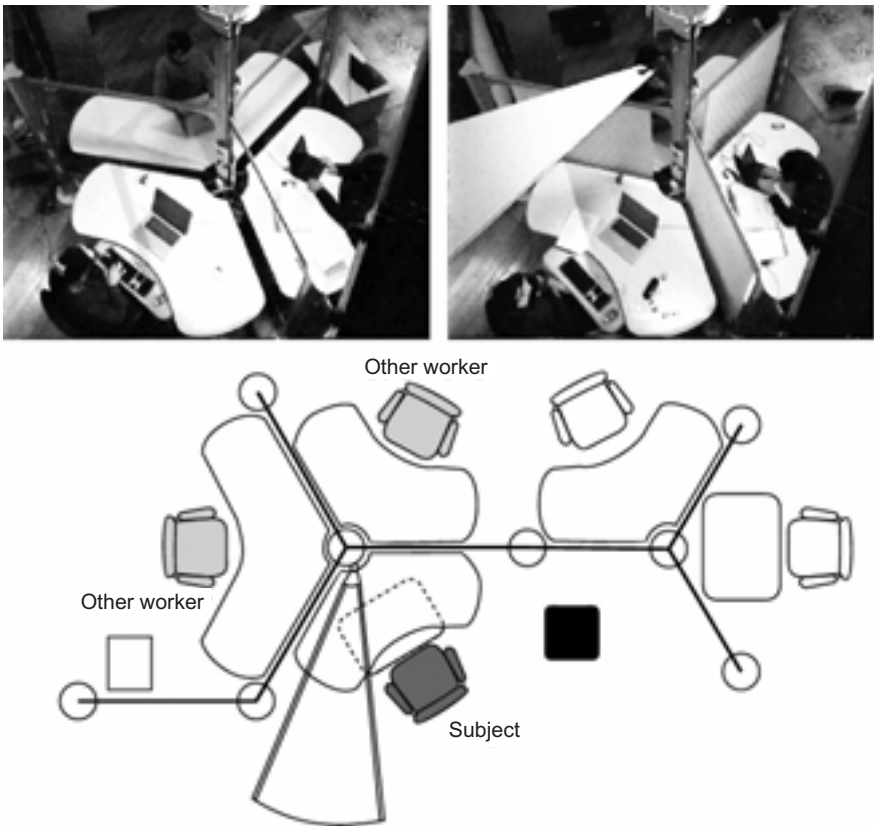

Figure 2. The office system used for the experiment. *Notes.* The top left photograph portrays the office without partitions. The photograph on the top right shows the same layout with partitions. The lower graphic depicts the placement of the participant and other workers.

3.3. Measuring Method

Eye movement measurements were conducted based on previous research by Noro and Tanaka (2001). A new analysis technique was used: classification of the locus. As shown in Figure 3, three visual targets were analyzed. Of these, the locus of eye movement during 30 min of work on a computer was sorted into three categories.

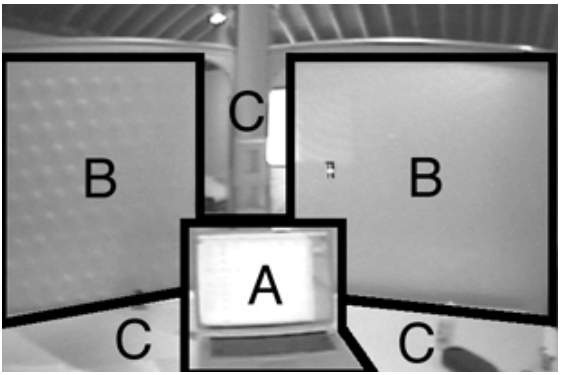

Figure 3. Images of sectioned visual targets. *Notes.* Area A represents looking at the computer monitor, Area B represents looking at a partition or a coworker, Area C represents looking at others.

3.4. Experimental Task

For this experiment, a group of three employees performed continuous work on a computer, as part of a team. Before the experiment, the workers had time to become accustomed to the different system.

4. RESULTS

Figure 4 shows the locus of the eye movements when participants spoke in the office without partitions. There was direct visual communication while they worked.

Figure 4. Locus of the eye movement while talking in the work place without partitions.

Figure 5 shows the locus of the eye movement when participants talked in the office with partitions. The figure indicates that the participant's eyes hardly caught coworkers, and overshot.

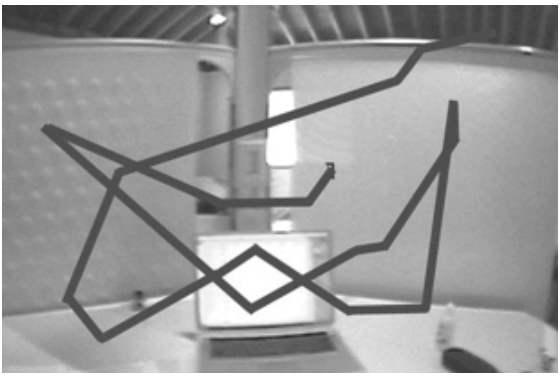

Figure 5. Locus of the eye movement while talking in the work place with partitions.

Figure 6 summarizes eye movements in the work place without partitions. While working on the computer, the participant's eyes periodically strayed from the computer monitor. This suggests the participant experienced some degree of distraction while performing concentrated work. These results correspond to computer-work-and-conversation previously described by Noro and Tanaka (2001).

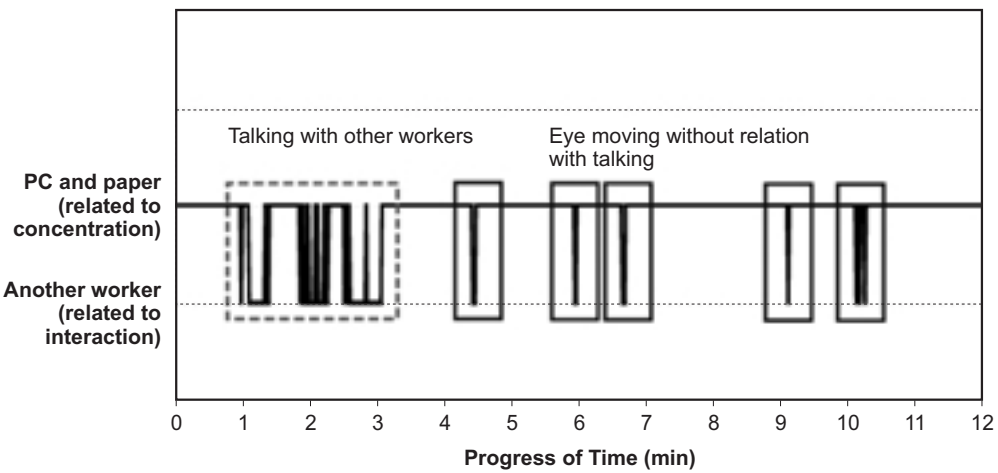

Figure 6. Classification of eye movements of the participant over 12 min (no-partitions condition). *Notes.* Figure 6 depicts typical eye movement while working in a work place without partitions. The *x* axis displays the progress of time. The *y* axis portrays the participant's visual targets. PC—personal computer.

Figure 7 summarizes eye movements in the work place with partitions. During computer work, the participant's eyes did not leave the computer monitor. This suggests the participant was able to concentrate on his work. The results correspond to personal computer (PC) work in the previous research done by Noro and Tanaka (2001).

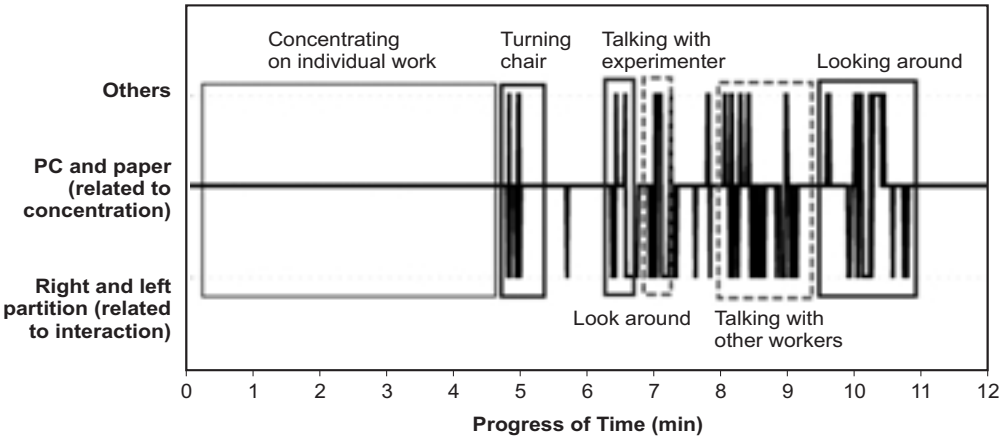

Figure 7. Classification of eye movements of the participant in 12 min with partitions. *Notes.* Figure 7 depicts typical eye movement while working in a work place without partitions. The *x* axis displays the progress of time. The *y* axis portrays the participant's visual targets.

5. CONCLUSIONS

5.1. A Comparison of Island- and Partition-Style

Findings indicate that intensive knowledge work requires both concentration and interaction. The use of eye movement measures in the current study enabled an analysis of the time spent on concentrating and on interacting with others. This approach represents a different approach to the performance of knowledge workers.

The results also show that the partition-style (a work place with partitions) is suitable for high-autonomy workers who need to concentrate. In contrast, the island-style work place without partitions is suitable for high-interaction workers.

Effective communication often requires open space designs. The current findings suggest that adding an area for meetings and interaction in the partition-style office can facilitate this requirement.

Figure 8 depicts the partition-style office in the current study, which includes a meeting section. It represents a solution for providing a proper environment for intensive knowledge workers in a limited space.

The latter issue is relevant in Japan because Japanese managers are experiencing strong pressures to save office space. The current findings justify the added space for meetings in an office.

Figure 8. Partition-style office includes meeting section.

5.2. Effectiveness of Eye Movement Measures

The current study used a different approach to analyze the locus of eye movement and its impact on office tasks involving both interaction and concentration. These measurements indicate that intensive knowledge work requires both concentration and interaction. The results showed the layout affected the ability to perform each of these tasks and pointed to a theoretical basis and criteria for selecting office layouts based on work style.

REFERENCES

Andersson, M., Berns, T., & Klusell, L. (2000). The TCO "Office Checker"—A tool for ergonomic work place evaluation. In *Proceedings of the IEA 2000/HFES 2000 Congress. July 29–August 4, 2000, San Diego, California USA* (pp. 1-659–1-662). Santa Monica, CA, USA: Human Factors and Ergonomic Society.

Benninghoven, A. (2002). Working conditions in callcenters: Successfully and healthy. In H. Luczak, A.E. Çakir, & Ç. Cakir (Eds.), *Proceedings of the conference WWDU 2002 world wide work* (pp. 188–189). Berlin, Germany: ERGONOMIC Institut fur Arbeits- und Sozialforschung Forschungsfesellschaft.

Brand, J.L., Hohne, J.J., Ku, Y.T.E., Lee, H.C., Luna, B., & Montgomery, L.D. (2000). Hemodynamic, performance & preference comparisons of three commercially available office chairs. In *Proceedings of the IEA 2000/HFES 2000 Congress. July 29–August 4, 2000, San Diego, California USA* (p. 3-226). Santa Monica, CA, USA: Human Factors and Ergonomic Society.

Brunnberg, H. (2000). Evaluation of flexible offices. In *Proceedings of the IEA 2000/HFES 2000 Congress. July 29–August 4, 2000, San Diego, California USA* (pp. 1-667–1-670). Santa Monica, CA, USA: Human Factors and Ergonomic Society.

Guimaraes, L.B.M., Fogliatto, F.S., & Belmonte, F. (2000). Analysis of motivational issues in the work environment—A case study from the banking sector. In *Proceedings of the IEA 2000/HFES 2000 Congress. July 29–August 4, 2000, San Diego, California USA* (pp. 2-309–2-311). Santa Monica, CA, USA: Human Factors and Ergonomic Society.

Guimaraes, L.B.M., & Linden, J.C.S. (2000). Macroergonomic design of a computerized office. In *Proceedings of the IEA 2000/HFES 2000 Congress. July 29–August 4, 2000, San Diego, California USA* (p. 2-329). Santa Monica, CA, USA: Human Factors and Ergonomic Society.

Jack, B.A., Roberts, K.A., & Wilson, R.W. (2003). Developing the skills to implement evidence based practice—A joint initiative between education and clinical practice. *Nurse Education in Practice, 3*(2), 112–118.

Kestler, E., & Romero, H. (2000). Research using the internet to complete ergonomics assessments of offices. In *Proceedings of the IEA 2000/HFES 2000 Congress. July 29–August 4, 2000, San Diego, California USA* (pp. 1-473–1-476). Santa Monica, CA, USA: Human Factors and Ergonomic Society.

Kincaid, W.H. (1999). Office ergonomics for maximum performance. *Occupational Hazards, 61*(5), 85–88.

Lewis, R.J., Krawiec, M., Confer, E., Agopsowicz, D., & Crandall, E. (2001). Musculoskeletal disorder worker compensation costs and injuries before and after an office ergonomics program. *International Journal of Industrial Ergonomics, 29*(2), 95–99.

Matarazzo, G., & Graziano, A. (2000). User centered design, training and innovation. Organizational change and development in the municipality of Rome. In *Proceedings of the IEA 2000/HFES 2000 Congress. July 29–August 4, 2000, San Diego, California USA* (pp. 2-189–2-192). Santa Monica, CA, USA: Human Factors and Ergonomic Society.

Noro, K., & Tanaka, R. (2001). Construction of virtual working environment and evaluation of the workers. In H. Arisawa, Y. Kambayashi, V. Kumar, H.C. Mayr, & I. Hunt (Eds.), *Conceptual modeling for new information systems technologies* (pp. 81–90). Berlin, Germany: Springer.

Petrelius, T. (2000). The distance working laboratory. In *Proceedings of the IEA 2000/HFES 2000 Congress. July 29–August 4, 2000, San Diego, California USA* (pp. 2-4–2-7). Santa Monica, CA, USA: Human Factors and Ergonomic Society.

Pregnolato, F. (2003). Call center—A participatory office. In H. Strasser, K. Kluth, H. Rausch, & H. Bubb (Eds.), *Quality of work and products in enterprises of the future* (pp. 633–636). Stuttgart, Germany: Ergonomia.

Robertson, M.M., Robinson, M., & Chen, P. (2000). Office ergonomics interventions: strategies and practices. In *Proceedings of the IEA 2000/HFES 2000 Congress. July 29–August 4, 2000, San Diego, California USA* (pp. 2-165–2-168). Santa Monica, CA, USA: Human Factors and Ergonomic Society.

Robertson, M.M., & Robinson, M. (2000). Systematic evaluation of office ergonomics training programs. In *Proceedings of the IEA 2000/HFES 2000 Congress. July 29–August 4, 2000, San Diego, California USA* (pp. 2-709–2-712). Santa Monica, CA, USA: Human Factors and Ergonomic Society.

Steelcase. (1997). *Steelcase general catalogue.* Grand Rapids, MI, USA: Author.

Weinstock, M.P. (1994). White-collar ergonomics: Is your office fit for duty? *Occupational Hazards, 56*(7), 27–30.