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When Should I Use my Active Workstation? The impact of Physical Demand and Task Difficulty on IT Users' Perception and Performance

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ABSTRACT

The seated position in our daily computer interactions has been identified as a major threat for health. Active workstations have been proposed as a healthy solution to these problems. However, research findings on the effects of such workstations on users' productivity is not conclusive. We argue that physical demand and task difficulty play a role in influencing IT users' performance and perceptions when using active workstations. An experiment manipulating task difficulty, direct and indirect physical demands was performed. Results suggest that task difficulty moderates the relationships between physical demand (direct and indirect) and users' perceptions and performance. Findings will help organizations and employees determine if it is appropriate for them to use active workstations.

Keywords: Sit-Stand Workstation, Physical Demand, HCI, Performance, Perception, Task Difficulty.

INTRODUCTION

The usage of Information Technology (IT) in a seated position in work environments has rapidly evolved over the past decades. While technology can bring major gains to businesses, this technological revolution is one of the main causes of physical inactivity (Straker, Levine and Campbell, 2009). This causes important health risks, even among people who adhere to physical activity recommendations. The problem arises from long sitting periods (Van der Ploeg, Chey, Korda, Banks and Bauman, 2012). In addition to the many health risks, research suggests that spending too much time sitting can also affect work performance, absenteeism, accidents, and can even have an impact on relationships (Sliter and Yuan, 2015, Pronk, Martinson, Kessler, Beck, Simon and Wang, 2004).

Thus, an important question is: can people be both active and productive at work? Although active workstations (AW) seem to be a promising solution, firms may have concerns before investing in this type of work equipment.

The literature is clear about AW health benefits, but there are mixed findings on their effect on employee performance. For example, some studies show that there is no difference between sitting and standing in terms of cognitive functions or task productivity (Russell, Summers, Tranent, Palmer, Cooley and Pedersen, 2016). It is also suggested that light physical activity can have cognitive benefits on simpler tasks, but could also have deleterious effects on more complex cognitive functions (Labonte-LeMoyne, Santhanam, Leger, Courtemanche, Fredette and Senecal, 2015).

Task performance depends mainly on physical demand and cognitive demand (Straker, et al., 2009). Evaluating the physical demand for an IT task in an AW context becomes necessary since the whole body is now interacting with the technology (Labonte-LeMoyne, Leger, Senecal and Santhanam, 2016). Fraizer and Mitra (2008) suggest that the effects of physicality might interfere between posture and cognition depending on the difficulty of the task. This could help explain the mixed findings about the relationship between AW and employee performance.

This paper investigates the effects of using an AW in the context of human computer interaction. In this context, AW can be defined as desks that demand light to very light levels of physical activity (Sliter and Yuan, 2015) and generate more physical demand than simply sitting in front of a computer (Jutras, Labonte-LeMoyne, Leger, Senecal, Mathieu and Begon, 2017). The objective of this experiment is to investigate how the physical demand of AW and the types of IT tasks performed influence users' perceptions and performance. We propose and empirically test a research model to assess which IT tasks are most suited for AW, using a sit-stand workstation, in a within-subject experimental design.

HYPOTHESIS DEVELOPMENT

Based on kinesiology literature, Labonte-LeMoyne, et al. (2016) proposed new constructs applicable to the field of Information Technology and Information Systems. The physicality of direct interaction is the "quantity and type of movement required from the user to control and interact with the technology" (Labonte-LeMoyne, et al., 2016). The physicality of indirect interaction with technology is the "physical positioning and movement of the user's body during the interaction with technology including that which is necessary to support the device" (Labonte-LeMoyne, et al., 2016).

Thus, to better understand the influence of AW on employee performance, these two constructs need to be investigated. As shown in Figure 1 we suggest that both types of physicality influence IT users' perceptions (i.e., attention, satisfaction, and stress) and performance (objective and perceived). We suggest that cognitive demand (i.e., the difficulty of the IT task) moderates these relationships.

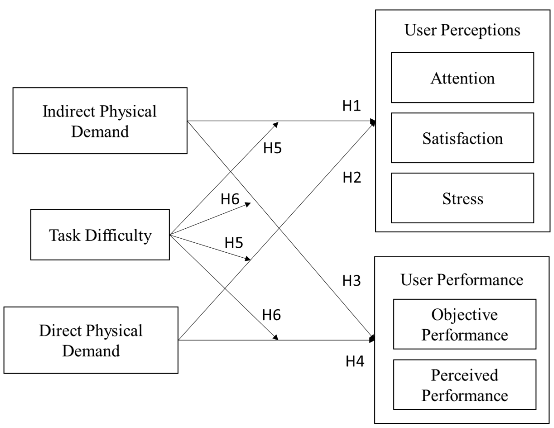

Figure 1. Research Model

The Impact of Physical Demand on User Perceptions

We expect an influence of the usage of AW on the perceived attention of the user. Woollacott and Shumway-Cook (2002) suggest that information processing capacity is limited and a task takes a portion of this capacity. Based on this definition, it may be that AW takes a certain portion of the user attention. Research also suggests that exercise positively impacts cognitive functions (i.e., attention) (Kramer, Hahn, Cohen, Banich, McAuley, Harrison, Chason, Vakil, Bardell and Boileau, 1999). It is also suggested that there is a relationship between postural control (i.e., indirect physical demand) and some aspects of cognition, such as attention but this relationship would vary depending on the difficulty of the task (Huxhold, Li, Schmiedek and Lindenberger, 2006).

One of the many goals of a good human computer interaction is to ensure that the technology can be used with satisfaction (Hartson, 1998). Prior research suggests that AW influence user satisfaction. Dutta, Walton and Pereira (2015) show that the usage of a sit-stand workstation resulted in a positive experience. Sliter and Yuan (2015) also suggest that light and very light physical activity seem to be effective in reducing depression and enhancing psychological well-being.

In a work environment, stress can have a significant impact on the psychological and physiological of the user. Research suggests that poor workstation design, the cognitive demand of a task, its postural demands, and job demands can contribute to higher levels of stress and anxiety (Smith, Conway and Karsh, 1999). On the other hand, Buckley, Hedge, Yates, Copeland, Loosemore, Hamer, Bradley and Dunstan (2015) suggest that AW could be a possible solution to reduce stress.

H1: The indirect physical demand has an impact on IT users' perceptions, specifically attention, satisfaction, and stress.

H2: The direct physical demand will have an impact on IT users' perceptions, specifically attention, satisfaction, and stress.

The Impact of Physical Demand on Task Performance

There are mixed findings in the literature regarding the influence of AW usage on task performance. To better understand this relationship, both types of physical demand need to be taken into account.

Direct physical demand may influence performance. For instance, Straker, et al. (2009) show that performance decrement was slightly larger for mouse tasks than for typing tasks. Although, light physical activity has a positive effect on cognitive performance (Chang, Labban, Gapin and Etnier, 2012), various indirect and direct physical demands may also influence performance. Thus, finding the right mix of direct (e.g., IT task) and indirect physical demand (type of AW) is key to improve work performance (Jutras, et al., 2017).

As shown in Straker, et al. (2009) and Commissaris, Konemann, Hiemstra-van Mastrigt, Burford, Botter, Douwes and Ellegast (2014), perceived performance was lower in all AW (i.e., walking and cycling) conditions, but not in the standing condition. This suggests that depending on the type of physical demand made by the AW, there could be an impact on perceived performance. We thus posit the following hypotheses.

H3: Indirect physical demand has an impact on perceived and objective IT task performance.

H4: Direct physical demand has an impact on perceived and objective IT task performance.

The Moderating Effect of Task Difficulty

As mentioned, task difficulty is a moderator in this study (Figure 1). By investigating the moderation effect of task difficulty, differentiated effects of direct and indirect physical demand on users' perceptions and performance can be isolated.

H5: Task difficulty moderates the relationship between (indirect and direct) physical demand and IT users' perceptions.

H6: Task difficulty moderates the relationship between (indirect and direct) physical demand and task performance.

METHODOLOGY

A laboratory experiment was conducted with a sample of 53 participants. A 2 (indirect physical demand: sitting/standing) x 2 (direct physical demand: low or high) x 2 (task difficulty: easy or hard) within-subject design was used. Participants were randomly assigned to either the seated or standing position for the first half of the experiment and they then changed to the other position for the remaining of the experiment, following a 15-minute break. The direct physical demand and the task difficulty conditions were randomized. Based on Jutras, et al. (2017), participants had to use a touch screen in the high direct physical demand condition and a computer mouse in the low direct physical demand condition. The task consisted of a standardized neuropsychological dual task memory span (Corsi and Michael, 1972) (See below for details). This test was selected because it induces cognitive states that are representative of office IT tasks, it could be performed on either a touch screen or with a mouse, and it can be manipulated in order to be easy or demanding in terms of cognitive load. Thus, each participant performed 8 tasks (i.e., sitting-mouse-easy, sitting-mouse hard, sitting-touchscreen-easy, etc.). A sit-stand AW (30 inches x 60 inches) was used (Anthrodesk, Etobicoke).

Participants

Of the 53 participants, the data of 40 participants (16 women) was usable for the final analysis due to technical difficulties and participants who did not meet the criteria for the study (e.g., health issues). Participants were university students and had to be 18 and over. Each was screened for neurological diagnostics, physical conditions, or any other health issue that could interfere with the experiment. The average age of participants was 24.1 ± 5.1. Based on the Body Mass Index (BMI) standard, 72.5% of them had a BMI in the range of a normal weight (between 18.5 and 24.9). Each participant received a 50$ gift card as a compensation.

Procedure

The study was approved by our institution's Ethical Research Board and participants had to provide their informed consent to participate. In addition to the 8 experimental tasks, a practice task was first performed to reduce potential task related learning biases. After each task, participants completed a questionnaire to assess their task perceptions (attention, satisfaction, stress, and performance). Finally, they completed a questionnaire containing demographic questions and in which their general comments on the use of active stations were also collected.

Tasks

The task performed for all 8 conditions was an adapted version of the Corsi block tapping task that assesses visuo-spatial working memory (Corsi and Michael, 1972) combined with a second task of simple memory span that assesses working memory. The dual task elicited working memory and tasks switching abilities, cognitive processes involved in office work.

Participants had to memorize the position on the screen of a sequence of squares (6 squares in the hard condition and 3 in the easy condition) first displayed on the screen. On the next screen, a letter appeared. Then, on the next screen, the participant had to enter the sequence of squares by clicking/touching their positions in the correct order. Participants had to perform this 5 times for the hard task (thus having 5 letters to remember) and 2 for the easy task (i.e., 2 letters to remember). Finally, the participant was asked to reproduce, in the correct order, the letters that had appeared between the sequences of squares. The participant had to do this whole process 3 times in the difficult condition and 9 times in the easy condition. The test was run using the psychology software tool E-prime (Sharpsburg, USA).

To evaluate the performance of the participants, responses were scored based on all or nothing for each sequence (Conway, Kane, Bunting, Hambrick, Wilhelm and Engle, 2005). We also measured the average reaction time (RT) of the sequences of squares and letters, as speed may influence score. We used the Inverse Efficiency Score (IES) (Townsend and Ashby, 1983) for the letters [Letter IES] and for the squares [Squares IES]. IES was calculated by dividing the RT by 1 minus the proportion of correct response for each sequence.

Measurement Scales

Users perception scores were obtained using validated measurement scales: Satisfaction (Sirdeshmukh, Singh and Sabol, 2002), Stress (Beaudry and Pinsonneault, 2005), Attention (Kanfer and Ackerman, 1989) and Performance (Commissaris, et al., 2014).

RESULTS

Statistical analysis were performed with Statistical Product and Service Solutions (SPSS) version 24 and Stata version 14. To examine the relationships hypothesized, we used multiple linear regression of least squares as well as logistic regression. To verify the potential effects of moderation or quasi-moderation (Sharma, Durand and Gur-Arie, 1981) of the difficulty of the task, we performed linear and hierarchical regressions.

The indirect physical demand (sitting and standing) had no significant impact on users' perceptions (Attention, Satisfaction, Stress, and Performance). Thus, H1 and H3 (perceived performance) are rejected. However, there is an interesting finding where satisfaction is positively impacted when the indirect physical demand is closer to 1 (the standing position) (3.037, $p \leq 0.10$). Direct physical demand negatively influences users' perceptions. Direct physical demand has a significant impact on Satisfaction (-3.038, $p \leq 0.05$) and a marginally significant impact on Attention (-0.0899, $p \leq 0.1$), Performance (-1.763, p≤ 0.10) and Stress (which is on an inverse scale, so it has a positive coefficient when using the touch screen resulting in an increasing level of stress (0.125, p≤0.10)). Thus, results support both H2 and H4 (perceived performance). Some control variables were significant. When the user had a better cardiovascular condition, significantly, the Satisfaction has a higher score (8.270, p≤0.10). Also, participants scored higher on the scale of Attention when they had higher cardiovascular capabilities (0.515, p≤ 0.05). Need For Touch impacted the dummy value of Attention. Higher NFT brought higher level of attention (0.563, p≤0.01).

Hypotheses H3 and H4 (objective performance) were tested simultaneously. We tested multiple variable of the task performance individually (i.e., Letter Score (%), Squares Score (%), Average Stimulus RT, Average letter RT, Letter IES, Squares IES). Indirect physical demand had a significant effect on Squares Score (%). It was higher in the standing condition (3.215, p≤0.01). Indirect physical demand did not impact other task performance variables. Thus, H3 (objective performance) is partially supported. The more there was a direct physical demand, the more it had a negative and significant impact on all performance variables (Letter Score (%): -5.340, p≤0.001; Squares Score: -5.461, p≤0.001; Average Stimulus (RT): 0.500, p≤0.001; Average letter (RT): 0.242, p≤0.001; Letter IES: 0.294, p≤0.001; Squares IES: 0.580, p≤ 0.001). Thus, H4 (objective performance) is supported. Again, some control variables were significant in relation to objective task performance. Higher value in NFT negatively impacted the score of the squares, RT, and IES (Squares Score (%): -1.686, p≤0.05; Average Stimulus (RT): 0.057, p≤0.01; Average letter (RT): 0.064, p≤0.01; Letter IES: 0.053, p≤ 0.10; Squares IES: 0.085, p≤0.01). Also, the more the experiment advanced, a decrease of RT was observed (Average Stimulus (RT): -0.031, p≤0.001; Average letter (RT): -0.040, p≤0.001; Letter IES: -0.057, p≤0.001; Squares IES: -0,031, p≤0.001).

In order to test the moderation effect for task difficulty, we tested a two-tailed level of significance for Fisher's test that compares the coefficient and to check the p-value of the moderator effect. By comparing an easy and hard task with direct and indirect conditions, we can conclude that the difficulty of the task is strongly significant for each condition. The difficulty of the task is a moderator. The difficulty of the task is then considered has a "quasi-moderator" since it is also a predictor of the dependent variables (Sharma et al. 1981).

By looking at the p-value of the Fisher test that compares the coefficients, results indicate that for an easy task, there is a significant difference for the Satisfaction, Squares Score (%), and Squares IES; where there is a preference for standing condition. For a difficult task, standing could enhance the Squares Score (%). For an easy task, results indicate a better perception and performance in the mouse condition (less direct physical demand). For a harder task, only the objective task performance is impacted negatively by the touch screen (greater direct physical demand), users' perceptions were not impacted.

Overall, the results suggest that task difficulty moderates the relationships between indirect physical demand and users' perceptions (attention, satisfaction, and stress) and between direct physical demand and users' (objective and perceived) performance, thus H5 and H6 are supported.

DISCUSSION

Since a large portion of IT users' work time is spent seated, organizations need to be involved in the development of this population-wide strategy. They also are directly affected by these issues since it could significantly affect work performance (Pronk, et al., 2004). Considering that sit-stand workstations propose higher levels of energy expenditure (Reiff, Marlatt and Dengel, 2012) and could reduce obesity, implementing them would be beneficial for both health and work performance benefits.

However, mixed findings in the literature about the relationship between active workstations and work performance do not make it easy for organizations to conclude on potential performance benefits. Thus, the objective of this study was to inform researchers and managers about the effects of active workstation physical demand and task difficulty on IT users' perceptions and performance.

We hypothesized that indirect physical demand would have an impact on users' perceptions (H1) and task performance (H3). Our results suggest that indirect physical demand has no impact on users' perceptions (H1). Similar findings have been reported in other studies (Roemmich, 2016). This is promising for the usage of active workstations as it shows no negative impact on work. At the performance level, with the results of H3, we can conclude that a higher level of indirect physical demand might bring benefits of using workstations for some tasks. These results are similar to those of Labonte-LeMoyne, et al. (2015). The fact that it did not negatively impact the score of the letter nor RT and IES, can suggest that standing will not impact performance and in some situations, it may even improve. This is also in line with the results of Chau, Sukala, Fedel, Do, Engelen, Kingham, Sainsbury and Bauman (2016) where productivity is not affected by the standing position. We also hypothesized that direct physical demand would have an impact on users' perceptions (H2) and task performance (H4). Results suggest that the more there is direct physical demand, the more it negatively affects user's perception (H2) in the context of an easy task. For both easy and hard tasks, performance (H4) is negatively affected by the usage of the touch screen (higher physical demand). Combining these findings with studies about task accuracy is of interest. Commissaris, et al. (2014) conclude that accuracy, for a short task, is strongly affected by an active workstation. Tasks with low direct physical demand that do not require too much accuracy could make a better fit of the active workstations. An interesting result is that the user perception was not significantly impacted for the direct physical demand (mouse, touch) for a harder task. This suggests that potential benefits are simply canceled out by the difficulty of the task (Labonte-LeMoyne, et al., 2015). Similarly, a harder task did not have any impact on perceptions. But results suggest that for an easy task, generally, standing generates better perceptions. As suggested by prior research, active workstations might have psychological benefits to individuals (Sliter and Yuan, 2015).

Contribution and Implications

To our knowledge, this study is the first to investigate the interaction between physical demand and task difficulty on user performance in the context of active workstations. The proposed research model is a first step toward better understanding the impact of physical demand on performance. For managers, our findings can help them determine what type of task should be performed on active workstations and also contribute to develop strategies that will fight the epidemic of sedentarity and obesity.

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