Visual Distraction Effects on Deliberate Focus Work

ORIGINAL RESEARCH FROM THE HAWORTH HUMAN PERFORMANCE LAB

Executive Summary

This study provides support for reducing visual distractions in workers' direct line of sight for time sensitive, high focus work. Specifically, it tested, when seated directly across from another worker in benching, *how much impact* does no visual screen, a 42" (from the floor) visual screen, or a 50" visual screen have on cognitive performance on a time-sensitive, high focus task while visual distractions are present? 50 people participated in a quasi-equivalent, control group experiment in which they completed a high focus cognitive task in these three different conditions compared to a control condition with no visual distractions. Performance (accuracy/error rates and speed), emotions, and stress levels were measured. Findings indicate that by reducing visual distractions in the direct line of sight for workers situated in benching, cognitive performance for tasks that require time-sensitive, deliberate focus work improves. Subsequently, stress levels may decline.

Theoretical Background

Distractions during focus work are problematic for workplace performance because they can use limited resources that are better served in paying attention to tasks requiring high focus. A review of recent research into neural/cognitive processes reveal mechanisms of (primarily visual) attention: 1) it can be automatically activated by salient stimuli (past experiences, relevance to the person) and intentionally guided by task (interests/goals), 2) once activated, the attentional process then allocates our limited neural resources for further cognitive processing, restricting attention to what is relevant[1] (or already attended to); 3) furthermore, it suppresses competing (non-salient) stimuli.[2] Intentional effort over attention, or attentional control, requires a higher cognitive load,[3] and occupies limited resources.[4] When these resources are further limited or depleted, additional attempts of attentional control become increasingly ineffective, subsequently lowering performance.

Since the challenge for optimal performance is to retain cognitive resources for the intended task, distractions divert those resources away from the task at hand.[5] Additionally, when and if our attention is captured by distraction, additional effort and cognitive resources must be expended to *regain* attentional control. Distractions, commonly thought of as stimuli that are irrelevant and unwanted to the task at hand, can come from external and internal sources, such as anything directly in our physical environment detected by our senses: visual, auditory, tactile, etc., our emotional state, a preoccupation with other thoughts, or physiological states i.e., discomfort. External sensory input typically is automatically processed (bottom-up); specifically, when presented with an unexpected visual or auditory cue[6] attentional capture occurs. Additionally, internal distractions, such as intense emotions, may impact attention not only by interfering with attention to an external task[7], but also in biasing selective attention processes.[8] Theoretically, as external and internal stimuli increase, they overload cognition thus reducing task performance which may increase stress. This experiment provides evidence for this hypothesis.

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[1] (Middlebrooks, Kerr, and Castel 2017)

[2] (Buschman and Kastner 2015)

[3] (Csikszentmihalyi 1990; Zhang et al. 2011; Shipstead, Harrison, and Engle 2015)

[4] (Gailliot et al. 2007)

[5] (Fukuda and Vogel 2011; Colflesh and Conway 2007; Conway et al. 2005; Kiyonaga, Egner, and Soto 2012)

[6] (Escera and Corral 2007; Sussman, Winkler, and Schröger 2003; Parmentier et al. 2011)

[7] (Dennis and Solomon 2010)

[8] (Becker and Leinenger 2011; Koster et al. 2010)

Experiment

Participants were office workers at a large mid-western manufacturing organization. Twenty-five men and twenty-five women with an average age of 43.66 years participated. Their roles in the organization were as follows: 2% intern/part-time employee, 60% regular staff, 28% managers, and 10% leaders.

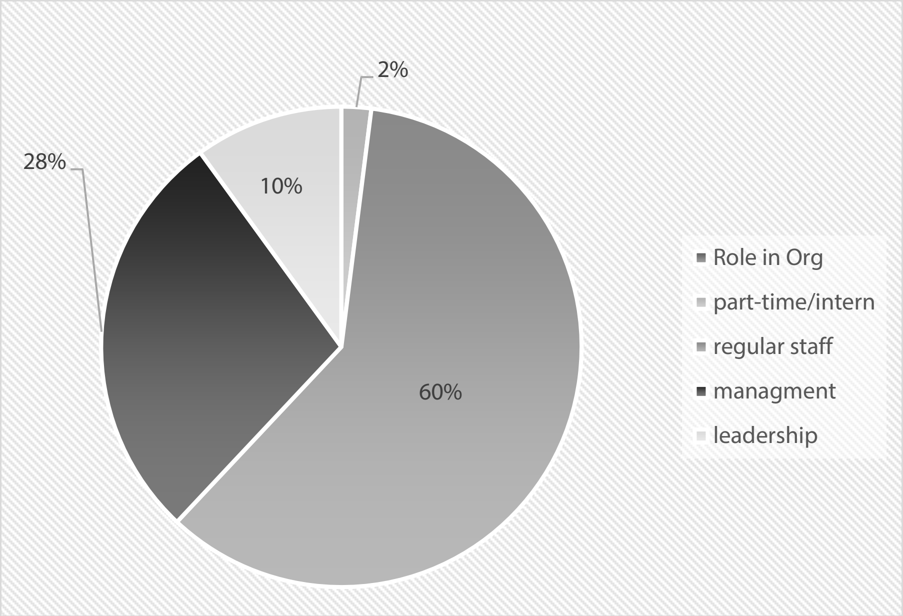

Figure 1. Percentage of Participant Roles in Organization

There were no differences in biological sex, average age, visual access in assigned workstation, role in organization, perceived difficulty in task instructions, or perceived difficulty in the task itself across the conditions. Therefore, quasi-equivalent groups were established across conditions for the experiment, increasing the ability to generalize the findings to populations similar in demographics to the participants in the study. All participants were provided informed consent upon arrival at the experiment setting. Biometric measurement sensors to measure GSR and emotion were placed and activated prior to starting the experiment. Participants were provided instruction for the high focus cognitive test. Once the test began, a researcher seated directly across from them performed visual distractions during the test. After the cognitive test, participants completed a short survey about perceptions and were debriefed.

Physical Context

The experiment room was set up with two tables together and chairs directly facing each other to replicate a benching scenario. Each participant's seated eye height was recorded and line of sight was calculated for each condition. The height of visual screen was manipulated: no screen, 42" screen, and 50" screen. The control condition was the same room. There was no visual screen or table directly across from participants, and participants completed the experiment while alone with no visual distractions.

Visual Distractions

The researcher employed the following visual distractions at timed intervals throughout the test: 1) drink from coffee cup; lift cup to face and replace it on the table once done, 2) stretch and yawn; reach both arms above the head, hold for 1-2 seconds and return to normal, 3) stand up and look at participant's keyboard as if interested; pause for 1-2 seconds before sitting back down.

Cognitive Performance

A computerized standard task-switching program recorded errors in the test as well as the duration to complete the test. Task switching in cognition involves concentration (controlled attention) to move attention from one task to another. Task switching consistently has a cognitive effort cost in that it isn't something that can be improved upon with practice beyond

initial learning of how to perform the task.[9] Participants were instructed the perform as accurately and as quickly as possible, and the test advanced if too much time was taken in the task-switch process.

Stress and Emotion Biometrics

Arousal and emotional experience were measured using a Galvanic skin response (GSR) sensor (arousal) and facial expression tracking camera (emotional experience). Combined, these measures indicated stress (arousal) and the valence of emotions experienced. GSR measures the electrical activity of skin. Skin conductance is governed by autonomic sympathetic activity, independent of cognitive control, and indicates emotional arousal.[10] A facial action coding system identified and analyzed macroexpressions, microexpressions, and categorized subtle expressions into action units which relate to more complex emotional responses as well as level of intensity of emotion.[11]

Perceptual Outcomes

After the task, perceptions of ease or difficulty were measured for understanding the instructions, the task itself, and ability to focus on the task and used a 7-point scale (1 = extremely easy to 7 = extremely difficult).

Results

Possible Confounding Variables

To rule out effects due to variables other than distractions and the conditions, several variables (biological sex, age, rank in organization, sitting eye height, and visual access in actual assigned workstation) were tested for confounding effects on all the outcomes measured: time and error rate for the cognitive test, expressions of positive and negative emotions (specifically frustration and confusion), and galvanic skin response. ANCOVA results revealed no confounding effects from these variables on the effects of visual distractions on outcomes.

Manipulation Checks for Task and Visual Distractions

Within-subjects results for the control group served as manipulation checks for the high-focus cognitive task and visual distractions. Per the performance time and accuracy results, manipulation of the high-focus cognitive task was successful. Recorded video feedback of actual distractions in different conditions revealed all distractions were visible in both the no screen and 42” screen condition. T-tests on outcome variables also support no difference between the no screen condition and the 42” screen condition. Therefore, the 42” screen condition was dropped from any tests treating visual distractions as an ordinal measure of the variable (regression/curve-fit analysis).

Visual Distraction Effects on Performance

There was no evidence that performance speed was affected by visual distractions as presented across all conditions. Participants were instructed it was a time-sensitive task and thus, may have not been willing to reduce speed by a significant amount in order to “perform well” or the test advanced without a response. In these instances where the test timed-out and advanced, these were recorded as errors. Thus, “errors” captured actual wrong choices as well as when too much time was taken to respond. Therefore, looking at errors, an initial ANOVA test for differences in error rates (accuracy) across the conditions and revealed significant differences: F (2, 31) = 3.326 p = .024. How much of these changes are directly caused by visual distractions?

Condition	*Avg. Errors*
No Visual Distractions (Control)	M = 1.83; SD = 1.33
Low Visual Distractions w/50” Screen	M = 7.07; SD = 5.94
High Visual Distractions w/No Screen	M = 11.00; SD = 9.66

Table 1. Average Error per Condition

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[9] (Stoet and Snyder 2007)

[10] (IMotions 2016b)

[11] (IMotions 2016a)

Regression analysis indicated that as visual distractions increased, errors also increased ($\beta = .402$; $p = .009$; $R^2 = .162$). Thus, 16% of the change in error rates during a high focus cognitive task were directly caused by exposure to visual distractions.

Visual Distraction Effects on Perceptions of Difficulty Focusing

Perceptions of difficulty focusing were assessed for the instructional period, all the tasks, and on ability to focus throughout the whole experiment. The ANOVA for difficulty focusing across conditions revealed significant differences: F (2, 31) = 2.524 p = .048. (Larger values indicate more perceived difficulty focusing.) How much of perceived ability to focus is directly caused by visual distractions?

Condition	*Avg. Perceived Difficulty Focusing*
No Visual Distractions (Control)	M = 2.83; SD = 1.72
Low Visual Distractions w/50" Screen	M = 2.86; SD = 1.70
High Visual Distractions w/No Screen	M = 4.07; SD = 1.33

Table 2. Average Perceived Difficulty Focusing

Regression analysis also indicates that as visual distractions declined, errors also declined ($\beta = .359$; $p = .037$; $R^2 = .129$). Thus, 13% of the change in perceived difficulty focusing during a high focus cognitive task was directly due to exposure to visual distractions.

Visual Distraction Effects on Stress: GSR Peaks

An initial ANOVA looking at differences across conditions in GSR peaks for all tasks was not significant, supporting the conclusion that amount of GSR peaks don't differ per amount of exposure to visual distraction. A non-parametric test of correlation only neared significance when treating conditions as an ordinal measure of exposure to visual distractions. This may warrant further investigation. Perceived difficulty focusing also was not related to GSR peaks.

Error Rates and Stress are Correlated During Focus Work

However, errors did predict autonomic nervous system arousal via GSR. A curve fit analysis between error rates (accuracy) and GSR peaks revealed that accuracy on high-load cognitive tasks had a quadratic relationship to GSR peaks. This relationship indicates that there was an optimal level of arousal needed to complete the task with no errors, then as arousal drops, errors increase. As errors continue to increase arousal also then increases: F (2,44) = 6.013; p = .005; Adj. $R^2 = .179$. The quadratic model indicated that 17.9% of any change in GSR peaks and errors were directly due to each other.

Since 16% of any change in errors were directly due to the presence of visual distractions, once errors started to occur, error rates may have mediated the effect visual distractions had on GSR peaks. Visual distractions did not directly impact GSR peaks, rather the errors impacted by visual distractions combined with all other errors not caused by visual distractions impacted 18% of any change in GSR peaks.

Visual Distraction Effects on Emotion During Focus Work

ANOVAs looking for differences across conditions in general expressions of positive emotion and negative emotions were not significant. Non-parametric tests of correlation also were not significant when treating conditions as an ordinal measure of exposure to visual distractions. Therefore, condition did not predict expressions of emotion. Biological sex is a better predictor of differences in expressions of negative emotion for the whole experiment with men expressing these more often than women. There were no biological sex differences for positive emotion. The results for confusion and frustration were identical to general expressions of negative emotion.

Conclusions

This study provides evidence that supports the theory that visual distractions increase cognitive load, pulling resources off high focus work. People exposed to various levels of visual distractions had higher error rates than people that experienced no visual distractions at all. Using a 42" screen shows no difference in performance than using no screen at all, whereas using a 50" screen does provide enough reduction in visual distractions to make a difference in performance. Reducing amount of exposure to visual distractions improved people's cognitive performance in terms of reducing error rates for high focus tasks by 16%; less distractions leads to less errors, and more distractions lead to more errors.

People exposed to the full amount of all the visual distractions presented (no screen) reported more difficulty focusing than all other conditions. Reducing the amount of visual distractions directly impacts any decline in people's perceived difficulty focusing by 13%. Visual distractions have no effect on performance speed, expressions of emotion, or stress.

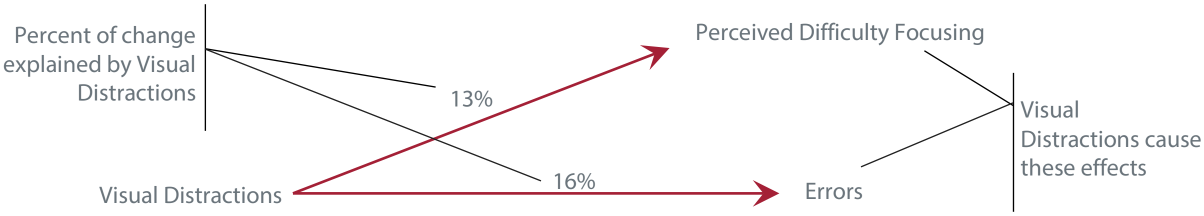

Figure 2. Direct Effects of Exposure to Visual Distractions During High Focus Work

However, error rates and stress responses have a *curvilinear* relationship. 18% of any change in stress levels (measured as autonomic nervous system arousal via GSR peaks) and errors are directly caused by each other.

How to Interpret These Results for Time-Sensitive, High Focus Work

People in benching that experience visual distractions in their direct line of sight may perform as "efficiently" as others in terms of speed, but their work is more likely to be of lower quality than if they work with no visual distractions directly in front of them. Considering the results for performance accuracy across conditions, relying on people's own self-reporting ease or difficulty focusing as the only means of gauging one's ability to perform well may not be accurate. It would be more accurate to pay attention to actual performance.

In terms of stress, visual distractions do not directly affect stress measured through the autonomic nervous system (GSR peaks). However, error rate has a curvilinear relationship with GSR peaks accounting for 18% of the shared variance. This provides evidence that to perform well enough to be perfectly accurate (zero errors), some level of arousal of the autonomic nervous system is necessary for cognitive and emotional engagement[12]; commonly referred to as "eustress" or adaptive/positive stress. As this arousal/engagement drops, error rates start to increase, and eventually as errors continue to accrue, arousal increases dramatically to the point when it becomes "distress" and is maladaptive/harmful and increases in errors continue. 18% of any change in error rates is directly due to changes stress and 18% of any change in stress is directly due to changes in error rates.

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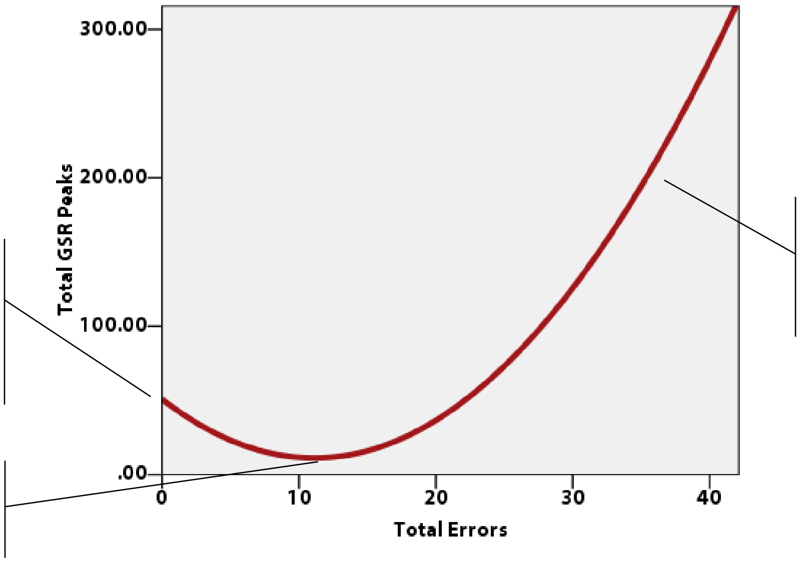
[12] (Duncan and Barrett 2007; Harmon-Jones, Price, and Gable 2012; Dawson, Schell, and Filion 2007)



Optimal level of arousal or *eustress* and perfect accuracy occur together

Very low arousal and errors occur together

High errors and high arousal or *distress* occur together

Figure 3. Stress Levels (GSR Peaks) & Error Rates: A Curvilinear Relationship

Lastly, visual distractions have no effect on emotional expressions in general, nor are emotional expressions related to measures of performance or stress. This holds true for specific negative expressions of confusion and frustration. Based on these results, it would be inaccurate to assume another's ability to perform well or another's stress levels based on negative facial expressions during time-sensitive, high focus tasks.

This study provides evidence that visual distractions increase cognitive load, pulling resources off high focus work. This causes more perceived difficulty focusing on the task at hand and lower performance in terms of work that is less accurate. Visual distractions do not directly affect stress. However, how well one is performing (in terms of accuracy of work) and stress responses are related in that, on average, workers experiencing higher errors also experience higher stress. 18% of any change in performance and stress are directly explained by each other.

Recommendations

In sum, visual distractions in the direct line of sight while seated in benching increase error rates for high focus work, which in turn impact stress experienced. Thus, it is recommended that for time-sensitive, high focus work, visual distractions in benching should be minimized as much as possible via product design and workplace design. Minimizing visual distractions is responsible for, *on average*, 16% of any increases in work performance for time-sensitive, high focus tasks. Subsequently, improvements in performance are responsible for 18% of any decreases in stress (and vice versa).

Directions for Future Research

Since the task switching program is a timed, high focus task, when participants took too long to respond, the test registered it as an error. Therefore, "errors" included wrong selections as well as when the test timed out. Wanting to pull apart speed and accuracy as measures of performance, it would be fruitful also to look at how completing a high focus task that is not time sensitive in the presence of visual distractions impact speed and error. Do people prioritize speed (efficiency) over quality? If quality is desired and distractions are present, speed may drop.[13] Lastly, how might these be related to stress experienced during the task?

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[13] (Middlebrooks, Kerr, and Castel 2017)

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